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USERS MANUAL FOR THE SLUDGEMAN MODEL FOR THE GROUNDWATER PATHWAY IN THE MONOFILLING OF SEWAGE SLUDGE

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Work Assignment Leader: Alexis Steen
Work Assignment Manager: Robert Southworth

Prepared by

ICF Technology, Inc.

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Submitted by

Battelle
Washington Environmental Program Office
2030 M Street, N.W.
8th Floor
Washington, D.C. 20036

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1.0 INTRODUCTION

One of the major options actively being considered for the disposal of municipal sewage sludges is landfilling. This option poses a risk to human health and the environment as a result of the presence of heavy metals and other toxic substances in the sludge. In order to reduce the risk to acceptable levels, the U.S. Environmental Protection Agency (EPA) has undertaken a regulatory program based on risk assessment and risk management. The key to such a program is the development of a methodology which allows quantifying the risk associated with the landfilling option. To provide such a methodology, a set of computer programs called SLUDGEMAN was created. SLUDGEMAN calculates a "reasonable worst case" level of human exposure to chemicals leaching from a landfill and being carried by the atmosphere. Exposure levels can then be compared to health criteria to determine if they are likely to cause unacceptable impacts.

This document is a user's manual for the SLUDGEMAN computer programs. It describes the computer system requirements for running SLUDGEMAN, gives an overview of SLUDGEMAN, including a brief description of the programs, and then describes the basics of running SLUDGEMAN -- how to load the disks, how to use the command files, and basically what to expect as the programs execute. Following this is a more detailed description of the programs, a brief explanation of the vapor pathway calculations, and finally a discussion of the command files used to run the SLUDGEMAN programs.

2.0 SYSTEM REQUIREMENTS

SLUDGEMAN requires the following computer system capabilities:

IBM PC or compatible

512 K minimum RAM

DOS 3.0 or higher

Dual floppy disk drive (preferable) or single floppy drive

3.0 OVERVIEW OF SLUDGEMAN

SLUDGEMAN is a set of computer programs designed to estimate concentrations at a user-defined downgradient location for 16 chemicals migrating from a landfill. The 16 chemicals are:

1) Arsenic
2) Cadmium
3) Copper
4) Lead
5) Mercury
6) Nickel
7) Benzene
8) Benzo(a)pyrene
9) Bis(2-ethylhexyl)phthalate
10) Chlordane
11) DDT/DDE/DDD
12) Dimethylnitrosamine
13) Lindane
14) PCBs
15) Trichloroethylene
16) Toxaphene

The SLUDGEMAN methodology has been developed to estimate the risk associated with disposal of a given sludge in a given landfill application site. Data on the sludge's composition and leachate characteristics, and the disposal site's setting are input to the model and the potential exposure to and risk from toxic constituents are calculated. This permits an important mode of operation for applicants who feel that special considerations with respect to their site should allow for higher sludge concentrations than the national criteria. They simply input specific data for their site into the model and show whether the resulting constituent concentrations exceed health criteria. However, the law specifically requires EPA to establish sludge criteria. As a consequence, SLUDGEMAN must also be run in a reverse mode starting with the health based acceptable dose level and working backward to determine how high a concentration of the toxic chemical could be tolerated before the acceptable dose level was exceeded.

For a given release time, with no sorption at the unsaturated/saturated zone interface due to eh/ph differences, the relationship between leachate concentration from a landfill and concentration at a downgradient monitoring point is linear. A given change in leachate concentration produces a corresponding change in outflow concentration. Thus, given the acceptable limits for outflow concentration, the allowable leachate concentration can be calculated. This is the case with organic chemicals. The law, however, specifies that criteria are to be based on concentrations in sludge, not in leachate. Therefore, the limiting leachate concentration must be related back to a limiting sludge concentration.

For organic contaminants, the relation between the sludge concentration and that of the leachate is defined by a partition or distribution coefficient. This coefficient defines a constant relationship between the sludge concentration Sc and the leachate concentration Lc such that $Sc=Lc*Kd$. The value for Kd can be derived from the organic carbon partition coefficient Koc which in turn is determined from the octanol-water partition coefficient Kow. The latter value has been determined empirically and reported for a wide range of chemicals. Using this approach, one needs only know the organic carbon content of the sludge to convert the Koc to the Kd by the relation Kd = Koc * Foc, where Foc is the organic carbon content of the sludge. With the Kd and the limiting leachate concentration determined by SLUDGEMAN, the limiting sludge concentration is calculated from Scl = Kd * Lcl.

For metal constituents, the relation is more difficult to define. Metal concentrations in leachate are often defined by solubility constraints rather than partitioning. In this case, leachate levels will stay at the solubility threshold regardless of the level of sludge concentration. What affects outflow concentration at a monitoring point is the duration of release of metals at the solubility limit. Given a constant recharge rate, chemical release time is governed by sludge concentration. The higher the sludge concentration, the longer the chemical is released, and the more the outflow concentration approaches the leachate concentration or solubility limit. The convention in SLUDGEMAN is to use the highest reported effluent or leachate value for the metal constituent and assume that defines the solubility limit. The sludge concentration is then varied to determine the inventory of contaminant producing maximum acceptable dose levels at the point of exposure.

It is recognized that different sludges will impact a metal's chemistry and, therefore, its maximum solubility level in leachate. To accomodate this sludge-specific factor, the regulations allow for an applicant to conduct a leachate test and determine actual leachate levels empirically. The relation thus derived from the sludge's total contaminant level and the leachate concentrations can thus be used to convert the limiting leachate concentrations to a sludge criteria for that site.

As mentioned, SLUDGEMAN has been written to back-calculate allowable dry weight sludge concentrations given health effects levels at the monitoring location. The back-calculation is not straightforward for some of the metals due to complicated geochemistry. Also, the sorption characteristics in the aquifer are not linear. Therefore, there is not a linear relationship between dry weight concentration and final concentration at the monitoring location.

This necessitates an iterative approach to solving for the allowable dry weight concentrations given the health effects levels. To carry out the iterative procedure, an initial set of dry weight concentrations are input to SLUDGEMAN. SLUDGEMAN then calculates output concentrations at the monitoring location using these inputs. These output concentrations are compared to the health effects levels for each chemical. The dry weight concentrations for each chemical are then adjusted appropriately, and SLUDGEMAN writes the new dry weight concentrations to a new input file to be used in another SLUDGEMAN run. SLUDGEMAN is then run again, the new results being again compared with the health effects levels, dry weight concentrations adjusted again, and a new input file written. After several such runs of SLUDGEMAN, the output concentrations should approach the health effects levels for the respective chemicals, and the dry weight concentrations approach the allowable sludge dry weight concentrations, which are the desired result.

Each time SLUDGEMAN is run, an output file is written which indicates how close the output concentrations are approaching the health effects levels. If output concentrations are within 1% of health effects levels, SLUDGEMAN indicates convergence has occurred by writing a 1.0 for a convergence factor in the output file, and no further adjustment is made to the dry weight concentrations for that chemical. This criterion was chosen because 1% seemed a sufficiently accurate value given the variability of many of the input parameters (depth to groundwater, hydraulic conductivity, hydraulic gradient, etc.), and a column of 1's is easy for a user to scan to see how convergence is progressing. If a user wishes to increase the match, the software would have to be revised.

If there seems to be no upper limit to the dry weight concentration for a given chemical, SLUDGEMAN limits the dry weight concentration to 10,000 mg/kg (1%). One percent chemical by weight seemed a reasonable upper limit, and SLUDGEMAN would be kept from spending needless time calculating unreasonable dry weight concentrations in cases, for example, in which the leachate concentration of a chemical was less than its health effects level.

Two types of analyses are performed by SLUDGEMAN, called Class 1 and Class 2. The Class 1 analysis predicts chemical concentrations at the saturated zone (aquifer) immediately upon entering that zone from the unsaturated zone above and after estimating chemical sorption in the saturated zone. The Class 2 analysis continues a step further by estimating concentrations at a downgradient point in the aquifer. Both analyses also estimate vapor concentrations for selected volatile chemicals at a user-defined distance downwind from the landfill. Results of the analyses include groundwater concentrations at the point of interest, background concentrations, vapor concentrations, the sum of these three, and health effects levels for the 16 chemicals simulated. This allows the user to compare the total concentration with the health effects level for each chemical and at the same time see which pathway is most significant to the final concentration, -- leachate from the landfill, vapor for volatile chemicals, or the background concentration.

For Class 2 aquifers, SLUDGEMAN calculates downgradient chemical concentrations on the centerline of the landfill. This is more conservative than estimating concentrations downgradient from the edge of the landfill as the highest chemical concentrations are expected along the centerline. Also, SLUDGEMAN simulates the landfill as existing along one edge of the aquifer, so that chemicals disperse laterally into the center of the aquifer from the edge. This yields higher concentrations downgradient from the landfill than would be calculated if the landfill were simulated as centered in the aquifer and lateral dispersion were allowed in both directions toward the sides of the aquifer. In reality, landfills can be placed in any location relative to an aquifer, so a landfill could be sited near one edge of an aquifer.

The SLUDGEMAN methodology consists of a series of data manipulation and transport simulation programs. The first two programs help the user create and edit the primary input file to SLUDGEMAN. The programs following those simulate the migration of chemicals from the landfill, through the unsaturated zone, and, for Class 2 aquifers, through the saturated zone. The final programs calculate vapor concentrations for the volatile chemicals, and summarize the results in the output files. A listing of the programs and a brief description of each is given below. A more detailed explanation of the programs is given in Section 5.

Class 1 Methodology

SLUDGIN.EXE
SLUDGFIX.EXE
SATM1.EXE
CHAIN.EXE
SATIT.EXE

Class 2 Methodology

SLUDGIN.EXE
SLUDGFIX.EXE
SLUGMAIN.EXE
CHAIN.EXE
AT123IN.EXE
AT123D.EXE
RESULT.EXE
ALLCON.EXE

Class 1 Methodology

SLUDGIN

SLUDGIN generates the basic input file for both the Class 1 and Class 2 aquifer analyses. It operates interactively with the user, prompting the user for the necessary inputs for SLUDGEMAN and writing them to the input file for the next program. A more detailed discussion of SLUDGIN is contained in Section 5.

SLUDGFIX

SLUDGEFIX allows making changes to the input file created by SLUDGIN. This is useful for correcting errors in input when running SLUDGIN, allowing the user to change his or her mind about a value previously entered, or changing a small number of values for subsequent SLUDGEMAN runs for testing sensitivity of the results to variation in individual parameters.

SATM1

SATM1 calculates the leach time of contaminants from the landfill and writes the input file for CHAIN.

CHAIN

CHAIN simulates chemical transport through the unsaturated zone below the landfill.

SATIT

SATIT is the last program run for Class 1 simulations. It finds the peak concentration in the output from CHAIN showing the time history of chemical concentrations exiting the unsaturated zone. SATIT also estimates the vapor concentration at a designated distance downwind of the landfill for those chemicals considered volatile.

SATIT writes an output file called SATIT.OUT containing the groundwater concentration contributed by the landfill, the background concentration, any vapor concentration from a volatilized contaminant, the sum of those three concentrations, the health effects level for each chemical simulated, and a factor indicating the ratio of health effects level to total concentration for each chemical. The user can see from the output file which pathway (landfill leachate, vapor, or background) is most significant to the total concentration, and how the total concentration compares with health effects levels for each chemical.

SATIT also writes a new SLUDGEMAN input file called SLFIXN.OUT to be used when back-calculating allowable sludge dry weight concentrations given the health effects levels to be achieved at a monitoring location. The user checks the last column of the SATIT.OUT file to see if any chemicals have not produced total output concentrations sufficiently close to their health effects levels. If some concentrations are still sufficiently far from their respective health effects levels, the user copies SLFIXN.OUT to SLUDGIN.OUT and reruns SLUDGEMAN. The new input values calculated by SATIT should yield output concentrations nearer the desired health effects levels.

Class 2 Methodogy

SLUDGIN

This SLUDGIN program is the same program used for Class 1 aquifers and is briefly described above.

SLUDGFIX

The Class 2 SLUDGFIX program is identical to that used for Class 1 simulations and is described briefly above.

SLUGMAIN

Because Class 2 simulations can require significant time to perform the saturated zone transport if all chemicals are simulated, SLUGMAIN performs two levels of screening calculations to eliminate chemicals whose concentrations are low enough to preclude them from further analysis. The two screening levels are called Tier 1 and Tier 2. The Tier 1 analysis consists of a simple comparison of the leachate concentration for each chemical with its health effects level. If the leachate concentration is below the health effects level, the chemical passes the Tier 1 analysis and is dropped from further consideration unless the user specifies that all chemicals are to be processed through the entire SLUDGEMAN analysis. The Tier 2 analysis calculates the level of degradation of degradable contaminants prior to reaching the saturated zone. Chemicals degrading below their health effects levels by the time they reach the saturated zone are dropped from further analysis unless the user specifies otherwise. Results of the Tier 1 and Tier 2 analyses are displayed on the user's terminal and written to a file called SLUGMAIN.DES. For chemicals passing the Tier 1 and Tier 2 analyses, or if the user specifies full analysis of all chemicals, SLUGMAIN writes an input file to the CHAIN program for unsaturated transport analysis.

As mentioned, the user has the option of having SLUDGEMAN carry out a full transport analysis of all chemicals, ignoring the results of the Tier 1 and Tier 2 analyses. At the beginning of SLUGMAIN, the user is asked if a full analysis of all chemicals is desired. If so, the Tier 1 and Tier 2 analyses are carried out and the results displayed to the user's screen, but all chemicals (unless they have no leachate concentrations) are passed on to the CHAIN or AT123D programs for transport simulation.

CHAIN

The CHAIN program for the Class 2 aquifer simulations is the same as that used in the Class 1 analyses.

AT123IN

AT123IN reads the output file from CHAIN, simulates chemical sorption in the aquifer if necessary, and prepares the input file to the AT123D program. AT123IN is run for Class 2 aquifers only, since for Class 1 aquifers no saturated zone transport is simulated. If no unsaturated zone exists, this program reads the necessary information from the preliminary AT123D input file, AT123D.TMP.

AT123D

AT123D is the saturated zone transport program which predicts the contaminant concentration at a point of interest downgradient from the landfill. AT123D is used for Class 2 aquifers only.

RESULT

RESULT reads the AT123D model output file and writes a brief summary containing peak groundwater concentrations, background concentrations, and unsaturated and saturated zone travel times for chemicals transported through the saturated zone.

ALLCON

ALLCON is the final program run for Class 2 aquifer simulations. ALLCON reads the peak groundwater concentration from RESULT, calculates any vapor concentrations contributed by volatile chemicals, sums those two concentrations with the background concentration, and writes out the three constituent concentrations, their sum, and the health effects level for each chemical to an output file called ALLCON.OUT. This gives the user a comparison of the total concentration of each chemical with the health effects level for that chemical, as well as the constituent contributions to that total concentration.

ALLCON also writes two additional columns to the ALLCON.OUT file which aid in back-calculating allowable dry weight concentrations. The columns contain scaled dry weight concentrations and the scale factor used in scaling. The scaling factor is the ratio of health effects level to total outflow concentration for each chemical. These factors immediately tell the user which chemicals have output concentrations which are close to their health effects levels and which do not. Thus, the user can quickly tell whether SLUDGEMAN needs to be rerun to more closely estimate dry weight concentrations that will produce outflow concentrations equaling chemical health effects levels.

ALLCON also writes another output file, called SLFIXN.OUT, which is used when back-calculating allowable sludge dry weight concentrations given the health effects levels to be achieved at a monitoring location. The SLFIXN.OUT file is a new input file to the SLUDGEMAN programs containing new dry weight concentrations which are the previous dry weight concentrations scaled by the factors in the last column of ALLCON.OUT. These new dry weight concentrations should produce output concentrations nearer the health effects levels for the respective chemicals.

When back-calculating allowable dry weight concentrations, the user checks the "F" column in the ALLCON.OUT file to see if any chemicals have not produced output concentrations sufficiently close to their health effects levels. If some concentrations are still sufficiently far from their respective health effects levels, the user copies SLFIXN.OUT to SLUDGIN.OUT and reruns SLUDGEMAN. The new input values calculated by ALLCON should yield output concentrations nearer the desired health effects levels.

For ease of operation, two command files have been developed which control the sequencing of the programs, SLUDGE1.BAT for Class 1 aquifer simulations, and SLUDGE.BAT for Class 2 aquifer simulations. The user simply types the name of the command file and the command file automatically executes the SLUDGEMAN programs in sequence. The command files are discussed in more detail in Section 7.

4.0 RUNNING SLUDGEMAN

The SLUDGEMAN methodology is contained on 3 disks. Two contain the methodology for Class 2 aquifers, simulating saturated zone transport to a point downgradient from a landfill boundary, and one disk contains the Class 1 aquifer methodology estimating concentrations at the saturated zone after sorption of some of the leachate in the aquifer. The programs contained on the disks are as follows:

Class 2 Methodology

Disk 1
- SLUDGE.BAT
- SLUDGIN.EXE
- SLUDGFIX.EXE
- SLUGMAIN.EXE
- CHAIN.EXE
- AT123IN.EXE

Disk 2
- SLUDGE.BAT
- AT123D.EXE
- RESULT.EXE
- ALLCON.EXE

Class 1 Methodology

Disk 1
- SLUDGE1.BAT
- SLUDGIN.EXE
- SLUDGFIX.EXE
- SATM1.EXE
- CHAIN.EXE
- SATIT.EXE

SLUDGEMAN requires a single 5.25-inch floppy disk drive containing the programs to be run. The programs are run off the floppy disk, and the input and output files are stored on the hard disk.

To run the programs of SLUDGEMAN, the user simply puts the disk labeled Disk 1 in the A drive, and types "A:SLUDGE." The computer then starts following the commands in the SLUDGE.BAT file. The SLUDGIN program notifies the user that it is running SLUDGIN, and then asks if an input file to SLUDGEMAN already exists or if one needs to be created. Ordinarily, for first runs, one must be created. Later, once the basic file is created, if the user wishes to change just one or two parameters in the file, it is better to say the file already exists at this point and then make the desired changes to the file with the second program in the series, SLUDGFIX.

If an input file must be created, the user types a 1 and SLUDGIN proceeds to prompt the user for the necessary parameter values to be entered into the input file. Once all the necessary values have been entered into the input file, SLUDGIN terminates, control is sent back to the command file, the command file commands the computer to execute the next program in the series, and the computer begins running the next program, SLUDGFIX.

SLUDGFIX allows the user to change any of the values in the input file. This allows for correcting any mistakes on entry when running SLUDGIN, changing one's mind about some of the values, or changing any of the values for subsequent runs of SLUDGEMAN when sensitivity of results to changes in input are desired. SLUDGFIX displays to the user a menu allowing the user to change values in a desired class of inputs without having to process through the entire list of variables to change the one(s) desired. Once the user has altered the input values desired, or exited the program with no alterations, SLUDGFIX terminates, and the next program in the series, SATM1 for Class 1 aquifers, or SLUGMAIN for Class 2 aquifers, is executed.

SATM1 requires no input from the user. It calculates the leach time from the landfill for each chemical, and writes the input file for the next program in the package, CHAIN, which simulates chemical transport through the unsaturated zone beneath the landfill.

SLUGMAIN requires only one input from the user, a 1 if the user wishes to perform a complete transport analysis on all chemicals, or a 0 if a complete transport analysis is to be performed only for those chemicals passing the Tier 1 and Tier 2 analyses. Regardless of the choice made, the Tier 1 and Tier 2 analyses are performed and the results displayed to the user's terminal. Preliminary screening of the chemicals is done to determine which can be excluded from a full transport simulation.

At this point, SLUDGEMAN is automatic as far as the user is concerned, requiring no further input from the user. The command file automatically runs the programs in sequence. First CHAIN is run, which simulates chemical transport through the unsaturated zone below the landfill. Then, either SATIT or AT123IN is run depending upon whether Class 1 or Class 2 aquifers are being simulated.

If Class 1 aquifers are being simulated, SATIT is run, and is the last program required for such simulation. SATIT calculates any concentrations due to airborne transport, adds such vapor concentrations to the leachate concentrations from the landfill and any background concentrations specified, and writes these three concentrations and their sum along with the health effects levels for each chemical to an output file called SATIT.OUT. SATIT.OUT is automatically written to the user's terminal, but the file is available to the user to view or edit at his or her convenience. An example of an output file from SATIT is shown in Appendix N.

If the user is back-calculating allowable dry weight concentrations for Class 1 aquifers, he or she checks the last column of the SATIT.OUT file to see if any chemical output concentrations differ significantly from their respective health effects levels. If some do, the user copies the SLFIXN.OUT file to SLUDGIN.OUT and reruns SLUDGEMAN for the Class 1 aquifer analysis.

AT123IN is executed if Class 2 aquifers are being simulated. AT123IN takes the peak output concentration from the CHAIN code and writes it along with other necessary information to the input file for the saturated transport code AT123D. AT123D is next run to calculate chemical concentrations in the aquifer at a desired distance downgradient from the landfill. After AT123D is completed, RESULT is run, which finds the maximum concentration output by AT123D (AT123D writes out a time history of chemical concentrations at the point of interest). Following RESULT, ALLCON is run, which is the final program run for Class 2 aquifer simulations. ALLCON serves a similar purpose to SATIT, in calculating vapor concentrations, and writing vapor concentrations, leachate concentrations, background concentrations, their sum, and health effects levels for all the chemicals simulated to an output file. The primary output file from ALLCON is called ALLCON.OUT, and is similarly displayed on the user's screen. An example of an ALLCON.OUT file is shown in Appendix M. The user examines this file to see if any chemical concentrations exceed their health effects levels at the monitoring location. Also, the user can see from this file which pathways -- landfill leachate, vapor, or background -- are most significant to the total output concentration.

If the user is back-calculating allowable dry weight concentrations for Class 2 aquifers, he or she checks the column labeled "F" in the ALLCON.OUT file to see if any chemical output concentrations differ significantly from their respective health effects levels. This is indicated by values in that column significantly different from 1. If some do, the user copies the SLFIXN.OUT file to SLUDGIN.OUT and reruns SLUDGEMAN for the Class 2 aquifer analysis.

A sample execution of SLUDGEMAN for Class 2 aquifers is provided in Appendix A. Class 1 aquifer simulations are essentially the same except that AT123IN, AT123D, RESULT, and ALLCON are not run and SATM1 is run instead of SLUGMAIN and SATIT is run instead of ALLCON.

5.0 DESCRIPTION OF SLUDGEMAN PROGRAMS

A more complete description of the SLUDGEMAN programs, including a discussion of the input and output files, is provided in this section. The programs are discussed in the order in which they appear in the SLUDGEMAN command file which is discussed in the next section.

SLUDGIN

The SLUDGIN program is designed to create the input file to the program SLUGMAIN. The program prompts the user for the required input data from the terminal. A discussion of these prompts, in the order in which they occur in the program, and the correct units required are provided in Appendix B.

If a data file already exists, the user has the option to exit the SLUDGIN program and proceed directly to the SLUDGFIX program. This is useful when making multiple SLUDGEMAN runs with single parameters changed per run. In this case, the user need not reenter all the values for each run, which would be required when running SLUDGIN, but can skip to SLUDGFIX where individual parameters can be changed.

Input and Output Files: There are two output files created by the program. The primary output file, SLUDGIN.OUT is a listing of the input data and is used as the input file to program SLUDGFIX. Appendix C shows the SLUDGIN.OUT file produced by the example run displayed in Appendix A. The second output file, SLUDGIN.DES, is a descriptor file, listing all the input data along with a short description of the values.

SLUDGFIX

The SLUDGFIX program allows the user the option of making changes to the input data file created by SLUDGIN. The user can change the data in twelve different categories rather than having to reenter a complete set of new data. A thirteenth category allows exiting the program if no changes are needed or the necessary changes have been made.

The thirteen categories are:

0) Exit "SLUDGFIX,"
1) Case Name,
2) Contaminant Name
3) Contaminant Concentration Data,
4) Sludge Data,
5) Site Data,
6) Unsaturated Zone Data,
7) Saturated Zone Data,
8) Partition Coefficients,
9) Contaminant Degradation Data,
10) Background Concentrations,
11) Effects Threshold Values, or
12) Vapor Parameters.

The user should select the number corresponding to the data category he wants to change. The current value for each variable within the category will be printed on the screen. The user has the option of entering a new value or retaining the existing value by entering <CR>. The user can proceed to a different category after making changes in the current category. Enter "0" to exit the SLUDGFIX program.

Input and Output Files: There are two input files and two output files to SLUDGFIX. The primary input file, SLUDGIN.OUT, was created in program SLUDGIN and provides SLUDGFIX with the initial input data set. The other input file is SLUDGE.SOR containing sorption data from the MINTEQ geochemical code for the six inorganics. The sorption data is shown in Appendix S. After changes are made to this initial data set, the data are written to two files: 1) SLUDGFIX.DES which lists the data along with descriptive lines and units, and 2) SLUDGFIX.OUT which contains just the revised data and is used as the input file to program SLUGMAIN. An example of the SLUDGIN.OUT file is shown in Appendix C. The SLUDGFIX.OUT file is identical to the SLUDGIN.OUT file except that any changes made in program SLUDGFIX appear in the SLUDGFIX.OUT file. An example SLUDGFIX.OUT file is shown in Appendix D. The SLUDGFIX.DES file is the same as the SLUDGIN.DES file except that it also includes the changes made by program SLUDGFIX. The purpose of SLUDGFIX.DES is to provide a thorough record of the case being simulated. An example SLUDGFIX.DES file is shown in Appendix E.

SLUGMAIN

The SLUGMAIN program performs Tier 1 and Tier 2 preliminary analyses for each contaminant of interest to determine which reach the water table at concentrations above their effects threshold values. Those contaminants reaching the water table at concentrations below their effects threshold values in either Tier 1 or Tier 2 are dropped from further consideration unless the user specifies otherwise. If any contaminant is above its threshold value, then further, more detailed analysis is required using the CHAIN and AT123D models. If the user so wishes, he or she can specify that all contaminants be analyzed with CHAIN and AT123D, in which case the Tier 1 and Tier 2 analyses are still carried out and the results written to the SLUGMAIN.DES file, but all chemicals (unless they have no leachate concentrations or there is no unsaturated zone) are passed on to the CHAIN program for simulation of transport through the unsaturated zone. The user is prompted early in the running of SLUGMAIN as to whether he or she wants full analysis of all chemicals or chemicals to be dropped upon passage of the Tier 1 or Tier 2 analyses.

Tier 1 and Tier 2 preliminary results are written to a descriptor file called SLUGMAIN.DES. Tier 1 is a simple comparison of the sludge leachate data to health criteria: if the leachate concentration is less than the health effects level for a given chemical, the constituent will not pose a health risk and is dropped from further analysis. The Tier 2 analysis checks any degradable chemicals for degradation below health effects levels before reaching the saturated zone.

Input and Output Files: SLUGMAIN requires one input file and produces four output files. The input file, SLUDGFIX.OUT, is the primary output file from SLUDGFIX which contains all the necessary input data. An example of this file is shown in Appendix D.

The four output files are called FLAG.FLG, SLUGMAIN.DES, CHAIN.INP, and AT123D.TMP. The FLAG.FLG file tells subsequent programs whether it is necessary to run the CHAIN and AT123D models. The file contains just two variables, each one set to either "0" or "1". A "0" for the first variable indicates that CHAIN does not need to be run. Either an unsaturated zone does not exist or the user requested Tier 1 and Tier 2 analyses and all contaminants passed the Tier 1 and 2 preliminary analyses in program SLUGMAIN. A "1" for the first variable means the unsaturated zone should be simulated with the CHAIN model. Similarly, a "0" for the second variable means all contaminants passed the preliminary Tier 1 and 2 analyses in program SLUGMAIN, thereby eliminating the need to run the AT123D model. A "1" for this variable means the model must be run. If the CHAIN model is run for the unsaturated zone (i.e., the first variable equals "1"), the AT123D model will always be run.

The SLUGMAIN.DES file describes the results of the Tier 1 and Tier 2 analyses. Information is provided on leachate concentrations, leach times from the landfill, leachable masses for the chemicals, volume of water drained to achieve sludge water capacity, chemical masses lost with that drainage, estimated unsaturated zone travel times, degradation constants, and estimated chemical concentrations at the saturated zone after transport and degradation through the unsaturated zone. An example SLUGMAIN.DES file is shown in Appendix F.

The CHAIN.INP file is the input file to the CHAIN model. The AT123D.TMP file is the initial input file to the AT123D model. This file is read by AT123IN and updated with information from the CHAIN model result file before being used as input to the AT123D model. Examples of the CHAIN.INP and AT123D.TMP files are shown in Appendix G and I, respectively.

SATM1

SATM1 is the Class 1 counterpart of SLUGMAIN. SLUGMAIN could have been used for Class 1 simulations, but since the Class 1 methodology is simpler than the Class 2, not requiring saturated zone transport using AT123D, it was decided that all chemicals could be analyzed fully in their transport to the aquifer. Hence the Tier 1 and Tier 2 calculations could be dispensed with and the input file for CHAIN could be created directly. The results of the Class 1 aquifer simulation show concentrations for all the chemicals just after sorption upon entering the saturated zone. If intermediate results are desired, SATM1 writes a descriptive file called SATM1.DES describing landfill and unsaturated zone parameters.

Input and Output Files. SATM1 writes two output files called LEACH.FIL and CHAIN.INP. LEACH.FIL is a simple listing of the chemicals and their leachate concentrations. This file is used by SATIT for chemicals not simulated by CHAIN (in the event there is no unsaturated zone or a chemical is not simulated and hence has a zero leachate concentration). CHAIN.INP is the input file for the next program, CHAIN.

CHAIN

The CHAIN model simulates the transport of contaminants across the unsaturated zone using an analytical procedure. The program was written by M. Th. van Genuchten and is a one-dimensional transport code simulating dispersion and first-order decay.

If the user requests Tier 1 and Tier 2 analyses, only those contaminants failing the Tier 1 and 2 preliminary analyses in program SLUGMAIN are passed to the CHAIN model. If an unsaturated zone does not exist or if all contaminants pass the Tier 1 and 2 preliminary analyses in program SLUGMAIN, the CHAIN model is not executed. There are no screen prompts for the CHAIN model.

Input and Output Files: The CHAIN model requires two input files and produces one output file. The FLAG.FLG input file tells the program whether or not it must be run. CHAIN is not run if an unsaturated zone does not exist, or if one does, if no contaminants failed the Tier 1 and 2 preliminary analyses in SLUGMAIN and those analyses were requested.

The primary input file to CHAIN is called CHAIN.INP. This file provides all the necessary data to run the model. A complete description of this file is provided in the CHAIN document (van Genuchten, 1985).

The only output file from CHAIN is called CHAIN.OUT. This file reports the results of the CHAIN model simulation and is used to pass these results to program AT123IN. This output file is also discussed in the document by van Genuchten (1985).

Examples of the CHAIN.INP and CHAIN.OUT files are shown in Appendices G and H, respectively.

AT123IN

The AT123IN program reads the CHAIN model results and prepares the input file for the AT123D model. More specifically, this program reads the peak output concentration and the pulse duration for each contaminant from the CHAIN model results and writes this information to the AT123D model input file.

For the six metals being simulated (arsenic, cadmium, copper, lead, mercury, and nickel), the peak concentration entering the saturated zone is decreased using the results of the MINTEQ code (Version A-1) in order to account for geochemical reactions that take place in the aquifer. This reduced concentration is input to the AT123D input file. The pulse time in the aquifer is increased by a factor equal to the pre-sorbed concentration divided by the sorbed concentration to allow for the time required for the contaminants to re-dissolve after sorption. The sorption data used (results of the MINTEQ code runs) are shown in Appendix S.

Since AT123D assumes an underground source with aquifer flow passing through it and requires the mass flux rate from this source as input, the output concentration from CHAIN needs to be converted to a mass flux rate from an appropriate source. The source for AT123D is taken as the area below the landfill to a depth in the aquifer equal to the mixing depth of the leachate from the landfill. The amount of contaminant mass leaching into the aquifer annually is the product of the concentration of each contaminant, the recharge rate, and the area of the landfill (length X width). The annual mass flux exiting the area below the landfill is either this amount if the groundwater flow rate is sufficient to carry all the mass away each year, or is a fraction of this amount equal to the fraction of the landfill length that the groundwater travels in a year. The mass flux from the area below the landfill is then the product of the contaminant leachate concentration, the recharge rate, the landfill width, and the minimum of the landfill length and the groundwater velocity expressed in distance per year. This is the value AT123IN writes into the AT123D input file for its required mass flux. If the groundwater flow is insufficient to carry away all the contaminant leachate that enters the aquifer each year, then the release time for contaminants into the aquifer is increased by the ratio of the length of the landfill to the annual groundwater travel distance to account for the increased length of time required to wash away all the contaminants from beneath the landfill.

If the Tier 1 and 2 preliminary analyses are requested in program SLUGMAIN, and all the chemicals pass those tests, then AT123D is not executed. There are no screen prompts for the AT123IN program.

Input and Output Files: AT123IN requires three input files and produces one output file. The FLAG.FLG input file tells the program whether or not it needs to be run. AT123IN is not run if the Tier 1 and Tier 2 analyses were requested and all the chemicals failed. Otherwise, it is run to create the input file for AT123D.

Another file used by AT123IN is CHAIN.OUT. CHAIN.OUT provides the peak concentrations and pulse times for each contaminant at the base of the unsaturated zone. This information is written into the AT123D model input file. The third input file is AT123D.TMP which is an initial AT123D model input file with all the necessary input data except the peak concentrations and pulse times. The only output file, AT123D.INP, is the input data file to the AT123D model.

Examples of the CHAIN.OUT, AT123D.TMP, and AT123D.INP files are shown in Appendixes H, I, and J, respectively.

SATIT

SATIT is the Class 1 counterpart of AT123IN. SATIT reads the output from CHAIN, finds the highest concentration for a given contaminant, calculates the concentration after sorption using the MINTEQ data, calculates an estimated vapor concentration due to airborne transport of volatilized chemicals, and writes the constituent pathway contributions as well as total concentration to a result file called SATIT.OUT. An example SATIT.OUT file is shown in Appendix N.

The SLUDGEMAN programs can also be operated in an iterative mode to estimate allowable dry weight concentrations given chemical health effects levels at the aquifer. This is done by running SLUDGEMAN with an initial set of dry weight concentrations, comparing the resultant output concentrations with the respective health effects levels, then adjusting the input concentrations accordingly, and rerunning SLUDGEMAN with these new input values. The new output concentrations are once again compared with their health effects levels, the input concentrations adjusted again, and SLUDGEMAN rerun with these new values.

To facilitate this operation, SATIT has been programmed to automatically carry out these calculations for the user. SATIT compares the total concentration (sum of the background, vapor, and leachate concentrations) with the health effects level for each chemical. If the total concentration differs from the health effects level by more than 1%, SATIT adjusts the dry weight concentration for that chemical so that on the next calculation, the total concentration for that chemical will be nearer its health effects level.

After processing all the chemicals simulated in the landfill, SATIT writes a new file SLUDGFIX.OUT file called SLFIXN.OUT containing the new dry weight concentrations. The user copies this file to SLUDGIN.OUT to produce a new input file to the SLUDGEMAN programs. The SLFIXN.OUT file can be input directly to SATM1, just like a SLUDGFIX.OUT file, but since execution of the SLUDGEMAN programs is designed to be controlled by the command file SLUDGE1.BAT, which executes the programs in order starting with SLUDGIN, the user should copy the SLFIXN.OUT file to SLUDGIN.OUT. Then, when the user reruns the programs by typing "A:SLUDGE1", and SLUDGIN begins to execute, the user should enter a "0" in response to the first prompt, indicating that a SLUDGIN.OUT data file already exists and that a new one should not be created. When SLUDGFIX is next executed, the user should enter a "0" to write a new SLUDGFIX.OUT file without making any changes since the new file is ready to be used in its entirety with the new dry weight concentrations.

If the user wishes, he or she can copy the SLFIXN.OUT file to SLUDGFIX.OUT, and then run each of the programs in turn by typing A:SATM1, then A:CHAIN, and finally A:SATIT. In this way, the user avoids running SLUDGIN and SLUDGFIX, which are not needed when rerunning the programs to calculate allowable dry weight concentrations. Or alternatively, the user can create an additional command file, say BACK1.BAT, containing execution of just SATM1, CHAIN, and SATIT for use when rerunning the programs repeatedly to converge on allowable dry weight concentrations.

The output file, SATIT.OUT, has a seventh data column labeled "F" containing a factor which is the ratio of the health effects level to the dry weight concentration for each chemical. This is an indication of how much the dry weight concentration must be scaled in order to produce the health effects level at the monitoring location. If, for example, the health effects level for a given chemical is half that chemical's output concentration, this factor would be 0.5. SATIT would then scale the dry weight concentration for that chemical down by half. This value may not produce an output concentration for that chemical exactly equaling its health effects level due to the non-linearity of the problem, but the new output concentration should be closer.

The factors in the "F" column of SATIT.OUT give a quick indication of how well convergence to the various chemical health effects levels is proceeding. Normally, the user continues rerunning SLUDGEMAN with new input files until all the factors in that column equal 1.0, indicating that the total concentrations for all chemicals are within 1% of their health effects levels. For chemicals whose leachate concentration and dry weight concentration are related through a known Kd, the convergence is fast, generally just one or two iterations. This is true of the organics. For the inorganics, however, which are generally solubility limited, or have a leachate concentration which is constant, convergence can be rather slow, the output concentration sometimes oscillating above and below the health effects level over a range of 3 to 1. This is especially true of arsenic, cadmium, and lead. Resolution of the MINTEQ sorption data may be a contributing factor. A small change in input concentration may produce a relatively large change in sorbed concentration due to interpolation between zero and the first data value in the MINTEQ table. This is especially true of low concentrations.

Once all the values in the "F" column equal 1.0, or the user is satisfied that they are reasonably close, the user discontinues rerunning SLUDGEMAN. The values in the column labeled "CS" are taken as the allowable dry weight concentrations. These are the latest dry weight concentrations calculated by SATIT.

AT123D

The AT123D model simulates the transport of contaminants from the point of entry into the saturated zone below the landfill to the monitoring location or facility boundary. If the Tier 1 and Tier 2 analyses were requested in SLUGMAIN, then only those contaminants that failed those analyses are passed to the AT123D model. There are no screen prompts for the AT123D model.

Input and Output Files: The AT123D model requires two input files and produces one output file. The FLAG.FLG input file tells the program whether it must be run. If the Tier 1 and 2 preliminary analyses in program SLUGMAIN were requested and all contaminants passed, then the AT123D model is not run.

The primary input file to the AT123D model is called AT123D.INP. This file provides all the necessary data to run the model. A complete description of this file is provided in the main AT123D document (Yeh, 1981).

The only output file from AT123D is called AT123D.OUT. This file reports the results of the AT123D model simulation and is used to pass these results to program RESULT. This output file is also discussed in the document by Yeh (1981).

Examples of the AT123D.INP and AT123D.OUT files are shown in Appendices J and K, respectively. Only a partial AT123D.OUT file is shown in Appendix K because the entire file is quite lengthy and only a portion of it is necessary to give the user an idea of what it contains. The user can run the example case shown in Appendix A and compare results to the output files in their entirety if he or she so chooses.

RESULT

The RESULT program reads the output file from the AT123D model, finds the peak concentration for each chemical, and writes an output file called RESULT.OUT containing the peak concentration at the monitoring location, effects threshold value, maximum concentration contributed by landfill, background concentration, and unsaturated and saturated travel times for the peak concentration. RESULT formerly was the final program of SLUDGEMAN until the vapor pathway calculations and iterative mode for back-calculating allowable dry weight concentrations were added to the package. There are no screen prompts for the RESULT program.

Input and Output Files: The RESULT program requires two input files and produces one output file. The FLAG.FLG input file tells the program whether any contaminants were run with AT123D. If not, RESULT is not run.

The primary input file to the RESULT program is the output file from the AT123D model, AT123D.OUT. This file provides the peak contaminant concentrations contributed by the landfill and the time for the peak to reach the monitoring location. The background concentrations for each contaminant, which were entered in the SLUDGIN program by the user, are also passed to the RESULT program in the AT123D.OUT file. The output file produced by RESULT is called RESULT.OUT. An example of a RESULT.OUT file is shown in Appendix L.

ALLCON

ALLCON is the final program run for Class 2 aquifer simulations. ALLCON is similar to SATIT for Class 1 aquifers, but uses the concentration after transport in the saturated zone as input instead of the concentration just after entering the aquifer from the unsaturated zone. Similar to SATIT, ALLCON estimates a vapor concentration for volatile chemicals at the monitoring point. The output file from ALLCON, called ALLCON.OUT, contains the concentrations at the monitoring point contributed by leachate from the landfill, any vapor concentrations from volatile chemicals, background concentrations, the sum of those three constituent concentrations, and the health effects levels for all chemicals.

As with SATIT, ALLCON is written to operate in an iterative mode. This is designed to allow automatic back-calculation of allowable dry weight concentrations in the landfill when health effects levels have been specified at the monitoring location. Given an initial set of dry weight concentrations for the 16 chemicals, the Class 2 SLUDGEMAN methodology estimates a set of concentrations for the chemicals at the monitoring location. ALLCON scales the dry weight concentrations by the ratio of the health effects levels to the resultant concentrations, and writes a new SLUDGEFIX.OUT file called SLFIXN.OUT containing those scaled concentrations as new dry weight concentrations. This file can be renamed SLUDGIN.OUT and "A:SLUDGE" typed to rerun the Class 2 methodology with this new set of dry weight concentrations. When SLUDGIN is run, which is the first program, enter a 0 when prompted about creating a new input file. Go directly to SLUDGFIX, using your new input file. Enter a 0 in response to the SLUDGFIX main menu, so that you skip directly to SLUGMAIN. From there, the methodology is automatic again, producing a new ALLCON.OUT file containing a new set of resultant concentrations at the monitoring location, and producing a new SLFIXN.OUT file containing new dry weight concentrations. If the resultant concentrations are still too different from the health effects levels, rename SLFIXN.OUT to SLUDGIN.OUT and type "A:SLUDGE" again. Keep cycling through the programs in this way until the resultant concentrations are sufficiently close to the health effects levels. As mentioned in the information on SATIT, convergence for some of the chemicals may be difficult. Notice that the output file from ALLCON is SLFIXN.OUT -- with an N. Don't rename SLUDGFIX.OUT to SLUDGIN.OUT or you will keep rerunning the same set of inputs. This won't do any harm, it just won't do you any good.

Input and Output Files. ALLCON uses three input files and produces three output files. ALLCON reads the RESULT.OUT file from RESULT to obtain the peak output concentrations at the monitoring location. Chemical background concentrations are also read from RESULT.OUT. ALLCON obtains chemical names and corresponding dry weight concentrations from SLUDGFIX.OUT. Vapor parameters are read from SLUDGFIX.OUT.

The primary output file from ALLCON is ALLCON.OUT. This file contains final leachate concentrations at the monitoring location, vapor concentrations for volatile chemicals, background concentrations, the total concentration due to the sum of those three, and the health effects levels for all the chemicals. Thus it is easy to compare total chemical concentrations at the monitoring location with health effects levels for the chemicals as well as see the constituent breakdown of that total. This file is displayed to the user's terminal. An example of an ALLCON.OUT file is shown in Appendix M.

The last two columns of the ALLCON.OUT file contain the sludge dry weight concentrations after adjustment by a scaling factor and the scaling factor used. The scaling factor is simply the ratio of the health effects level for a given chemical to the total concentration at the monitoring location for that chemical. This indicates how the input dry weight concentrations need to be changed in order to produce output concentrations at the monitoring location more closely equaling the health effects levels. If the total concentration of a chemical is within 1% of its health effects level, the factor is set to 1. This gives the user a quick indication of how convergence is proceeding for all the chemicals.

If the output concentration for a given chemical is always lower than the health effects level no matter how high the dry weight concentration is increased, then the dry weight concentration is set to 10000 and the factor is set to 1 indicating convergence. Dry weight concentrations are in mg/kg, so a value of 10000 represents a concentration of 10 grams of chemical to 1000 grams of sludge solids. That seems a reasonable upper limit for dry weight concentrations.

For back-calculating allowable dry weight concentrations given concentration limits at the monitoring location, another file is created called SLFIXN.OUT. Note the "N" for "New" in the file name. It is essentially a new SLUDGFIX.OUT file. When using the command files SLUDGE.BAT and SLUDGE1.BAT supplied with the SLUDGEMAN methodology, SLFIXN.OUT is renamed SLUDGIN.OUT and essentially becomes an output file of SLUDGIN. It is named SLFIXN.OUT, associating it with

SLUDGFIX, because it is also essentially an output file of SLUDGFIX, requiring no further modifications of the input values, and SLUDGFIX.OUT is the primary input file to the calculational programs of SLUDGEMAN. Ideally, when running the SLUDGEMAN programs repeatedly for converging to allowable dry weight concentrations, SLFIXN.OUT would be renamed SLUDGFIX.OUT and the first two programs, SLUDGIN and SLUDGFIX, would be skipped. But when using the command files SLUDGE.BAT and SLUDGE1.BAT, it is necessary to rerun SLUDGIN and SLUDGFIX, hence SLFIXN.OUT must be renamed SLUDGIN.OUT to avoid overwriting it with the original file when SLUDGFIX copies the SLUDGIN.OUT file to SLUDGFIX.OUT. Ideally, in this case, the user should create another command file, perhaps named CONV.BAT, identical to SLUDGE.BAT or SLUDGE1.BAT, but with the commands to run the first two programs commented out. In this way, only the programs beginning with SATM1 and SLUGMAIN would be run. Then the SLFIXN.OUT file would be renamed SLUDGFIX.OUT and the new command file executed.

6.0 VAPOR PATHWAY CALCULATION

Some chemicals in municipal sewage sludge are highly volatile and may present an inhalation hazard downwind of a landfill site. To account for the contribution of such vapor concentrations to the overall concentration at a downgradient point of interest, SATIT and ALLCON calculate vapor concentrations for selected chemicals at a user defined distance downwind of the landfill.

The total time during which the landfill is assumed to allow chemicals to evaporate from the landfill is 70 years. The landfill is assumed active for 20 years of those 70, during which the sludge deposited each day is assumed open to the air for an average of 4 hours. So the sludge is assumed open to the air 1/6 of the time for the first 20 years, covered with a temporary cover 5/6 of that time, and covered with a final cover for 50 years.

The rate at which chemicals evaporate from the landfill is estimated by use of Henry's Law constants. Henry's Law constants indicate the ratio of vapor concentration above a pool of liquid to the liquid concentration. During the time the landfill is covered, the rate of evaporation is modified by the thickness and porosity of the cover material. Cover thickness and porosity for active and post-closure periods are specified by the user.

Other factors affecting volatilization and transport of chemicals from a landfill are the molecular weights of the chemicals considered, surface wind velocity, air temperature, distance to the monitoring location, active landfill cell dimensions, and overall landfill dimensions. Values for these parameters are input by the user.

Presently, the programs have been written to calculate vapor concentrations for 6 of the 10 organics: benzo(a)pyrene, bis(2-ethylhexyl)- phthalate, chlordane, DDT/DDD/DDE, dimethylnitrosamine, and PCBs. Dimensionless Henry's Law constants and molecular weights and have been incorporated into the programs for these chemicals. The default values used for these parameters are shown in Appendix R. The values for Henry's Law constants were obtained from publications by Lyman et al., 1982, and the molecular weights from EPA Hazard Profiles for the respective chemicals.

Since total chemical concentrations at a monitoring location are desired, the calculated vapor concentration for each chemical must be added to that of the leachate and background concentrations for that chemical. Since SATIT and ALLCON calculate vapor concentrations in micrograms of chemical per cubic meter of air and the liquid concentrations are calculated in milligrams of chemical per liter of water, the vapor concentrations need to be converted to equivalent liquid concentrations before they can be summed to produce a total concentration that can be compared with health effects levels.

According to EPA, a 70-kilogram person breathes about 20 cubic meters of air per day and drinks about 2 liters of water per day. So, if the air contains 1 microgram of a chemical per cubic meter, the person is breathing 20 micrograms of the chemical per day. Since the person is assumed to drink about 2 liters of water per day, 20 micrograms inhaled daily is equivalent to drinking water containing 10 micrograms per liter. Ten micrograms per liter is equivalent to 0.01 milligrams per liter. So, 1 microgram per cubic meter vapor concentration is equivalent to 0.01 milligram per liter liquid concentration, under these assumptions. Therefore, SATIT and ALLCON multiply the vapor concentration in micrograms per cubic meter by 0.01 to convert to equivalent liquid concentrations in milligrams per liter before summing the constituent concentrations for comparison with health effects levels.

Example output files from ALLCON and SATIT are shown in Appendices M and N, respectively. Contained in the output files are the constituent concentrations comprising the total concentration for each chemical. This immediately shows the user which pathway is most significant to the final concentration -- whether leachate from the landfill, vaporization for volatile chemicals, or the existing background concentration.

7.0 SLUDGEMAN COMMAND FILES

Two computer command files have been developed to facilitate the operation of the SLUDGEMAN methodology, one for Class 1 aquifer simulations called SLUDGE1.BAT, and the other for Class 2 simulations called SLUDGE.BAT. The command files are sometimes called batch files, since each consists of a batch of commands, hence the ".BAT" extension on the file names. The programs run by each command file are as follows:

Class 1 Methodology

SLUDGE1.BAT
1) SLUDGIN.EXE
2) SLUDGFIX.EXE
3) SATM1.EXE
4) CHAIN.EXE
5) SATIT.EXE

Class 2 Methodology

SLUDGE.BAT
1) SLUDGIN.EXE
2) SLUDGFIX.EXE
3) SLUGMAIN.EXE
4) CHAIN.EXE
5) AT123IN.EXE
6) AT123D.EXE
7) RESULT.EXE
8) ALLCON.EXE

The command files run each program in sequence. The programs run off the A disk drive and write all the input, output, and result files to the C drive.

To use the command files, simply type "A:SLUDGE1" for Class 1 aquifer simulations, or "A:SLUDGE" for Class 2 aquifers. These commands direct the computer to look to these files for instruction. The computer then begins sequentially executing the commands in the files. Lines beginning with a :C in the first column are comment lines for the purpose of describing the instructions in the files. Other statements are instructions telling the computer to run programs or type messages to the user's terminal. The command files SLUDGE.BAT and SLUDGE1.BAT are shown in Appendixes P and Q, respectively.

Appendix A. Example Run of SLUDGEMAN

```
A>sludge
Strike a key when ready . . .

A>A:SLUDGIN.EXE
     ****************************************
     *          PROGRAM SLUDGIN             *
     *       DRAFT COMMENT VERSION 0.0      *
     *                                      *
     *   WELCOME TO THE SLUDGEMAN COMPUTER  *
     *    PROGRAM FOR EVALUATING LANDFILL   *
     * DISPOSAL OF MUNICIPAL SEWAGE SLUDGE  *
     *                                      *
     ****************************************


     SLUDGEMAN WILL NOW CREATE AN INPUT DATA
     FILE USING THE DATA FOR YOUR SITE.
     IF YOU HAVE NOT ENTERED DATA FOR THIS
     SITE OR APPLICATION BEFORE, ENTER 1,
     OTHERWISE ENTER 0

     ENTER 1 TO CREATE NEW DATA FILE
     ENTER 0 IF DATA FILE ALREADY EXISTS
1

ENTER THE CASE NAME
sludgeman test case

ENTER LEACHATE CONCENTRATION (MG/L) FOR ARSENIC
2.0
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR ARSENIC
1.0
ENTER LEACHATE CONCENTRATION (MG/L) FOR CADMIUM
.2
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR CADMIUM
13.821
ENTER LEACHATE CONCENTRATION (MG/L) FOR COPPER
37.
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR COPPER
10000.
ENTER LEACHATE CONCENTRATION (MG/L) FOR LEAD
10.
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR LEAD
1185.5
ENTER LEACHATE CONCENTRATION (MG/L) FOR MERCURY
.69
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR MERCURY
```

Appendix A, Example SLUDGEMAN Run, continued.

```
54.927
ENTER LEACHATE CONCENTRATION (MG/L) FOR NICKEL
3.4
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR NICKEL
10000.
ENTER LEACHATE CONCENTRATION (MG/L) FOR BENZENE
.030918
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR BENZENE
1.7007
ENTER LEACHATE CONCENTRATION (MG/L) FOR BENZO(A)PYRENE
1.8563E-04
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR BENZO(A)PYRENE
59.88
ENTER LEACHATE CONCENTRATION (MG/L) FOR BIS(2ETHEX)PTHALATE
8.7769
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR BIS(2ETHEX)PTHALATE
161.04
ENTER LEACHATE CONCENTRATION (MG/L) FOR CHLORDANE
.11667
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR CHLORDANE
10000.
ENTER LEACHATE CONCENTRATION (MG/L) FOR DDT/DDE/DDD
.59444
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR DDT/DDE/DDD
55.297
ENTER LEACHATE CONCENTRATION (MG/L) FOR DIMETHYLNITROSAMINE
3.6084E-04
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR DIMETHYLNITROSAMINE
7.0114E-3
ENTER LEACHATE CONCENTRATION (MG/L) FOR LINDANE
17.728
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR LINDANE
10000.
ENTER LEACHATE CONCENTRATION (MG/L) FOR PCBS
1.6764E-04
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR PCBS
269.57
ENTER LEACHATE CONCENTRATION (MG/L) FOR TRICHLOROETHYLENE
.18469
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR TRICHLOROETHYLENE
18.315
ENTER LEACHATE CONCENTRATION (MG/L) FOR TOXAPHENE
3.0896E-02
ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR TOXAPHENE
14.925
ENTER SLUDGE MOISTURE CONTENT (KG/KG)
.80
ENTER SLUDGE STORAGE CAPACITY (KG/KG)
.90
ENTER SLUDGE DENSITY (KG/CU M)
1025.
```

```
ENTER NET RECHARGE (M/YR)
.25
ENTER DISTANCE FROM LANDFILL BOUNDARY TO MONITORING LOCATION (M)
150.
ENTER LANDFILL WIDTH (M) (PERPENDICULAR TO THE FLOW PATH
100.
ENTER LANDFILL LENGTH (M)
100.
ENTER FILL HEIGHT (M)
3.
ENTER AN AVERAGE LONGITUDINAL DISPERSIVITY VALUE
FOR THE ENTIRE UNSATURATED ZONE.
A VALUE OF 0.1 THE DEPTH TO GROUNDWATER FROM THE BOTTOM
OF THE LANDFILL MAY BE A REASONABLE VALUE.
1.
ENTER NUMBER OF LAYERS IN UNSATURATED ZONE (1 TO 5 ALLOWED)
1
ENTER MATERIAL TYPE FOR LAYER  1
 1 - CLAY
 2 - SILTY CLAY
 3 - SILTY CLAY LOAM
 4 - CLAY LOAM
 5 - SANDY CLAY LOAM
 6 - SANDY SILT LOAM
 7 - SILTY LOAM
 8 - SANDY LOAM
 9 - LOAMY SAND
10 - SAND
11 - FRACTURED SANDSTONE
12 - FRACTURED LIMESTONE
10
ENTER THICKNESS OF LAYER  1 (M)
10.
A REASONABLE VALUE OF SATURATED HYDRAULIC CONDUCTIVTY
FOR THIS MATERIAL WOULD BE  3.200E+03 M/YR

DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y=1, N=0)
1
ENTER A NEW HYDRAULIC CONDUCTIVITY FOR LAYER  1 (M/YR)
10000.
A REASONABLE VALUE OF SLOPE OF SOIL CURVE
("B VALUE") FOR THIS MATERIAL WOULD BE     4.0000

DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y=1, N=0)

A REASONABLE VALUE OF EFFECTIVE POROSITY
FOR THIS MATERIAL WOULD BE     0.3400 CU M/CU M

DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y=1, N=0)
1
```

```
ENTER A NEW EFFECTIVE POROSITY FOR LAYER  1 (CU M/CU M)
.39

A REASONABLE VALUE OF EFFECTIVE BULK DENSITY
FOR THIS MATERIAL WOULD BE  1750.0000 KG/CU M

DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y-1, N-0)
1

ENTER A NEW VALUE OF EFFECTIVE BULK DENSITY
1400.

DO YOU WISH TO ENTER KD VALUES FOR THE
UNSATURATED ZONE OR USE DEFAULT VALUES?
  ENTER 0 TO USE DEFAULT VALUES OR
  ENTER 1 TO ENTER VALUES

SELECT DESIRED OPTION FOR UNSATURATED ZONE
DEGRADATION RATE CONSTANTS:
(0) USE AEROBIC DECAY RATES
(1) USE ANAEROBIC DECAY RATES
(2) SPECIFY USER DEFINED DECAY RATES

SELECT THE APPROPRIATE GROUNDWATER PH (SU)
AND EH (MV) CATEGORY.  IF THE ACTUAL PH AND EH VALUES
ARE NOT LISTED, TO BE CONSERVATIVE, SELECT THE LOWER
PH VALUE AND THE HIGHER EH VALUE
         1 - PH 6.0, EH -200
         2 - PH 6.0, EH +150
         3 - PH 6.0, EH +500
         4 - PH 7.0, EH -200
         5 - PH 7.0, EH +150
         6 - PH 7.0, EH +500
3
ENTER MATERIAL TYPE FOR SATURATED ZONE
 1 - CLAY
 2 - SILTY CLAY
 3 - SILTY CLAY LOAM
 4 - CLAY LOAM
 5 - SANDY CLAY LOAM
 6 - SANDY SILT LOAM
 7 - SILTY LOAM
 8 - SANDY LOAM
 9 - LOAMY SAND
10 - SAND
11 - FRACTURED SANDSTONE
12 - FRACTURED LIMESTONE
10
```

Appendix A, Example SLUDGEMAN Run, continued.

```
A REASONABLE VALUE OF SATURATED HYDRAULIC CONDUCTIVTY
FOR THIS MATERIAL WOULD BE   3200.000 M/YR
DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y=1, N=0)
1
ENTER A NEW AQUIFER HYDRAULIC CONDUCTIVITY (M/YR)
1000.

ENTER AQUIFER EFFECTIVE POROSITY (CU M/CU M)
.1
ENTER AQUIFER HYDRAULIC GRADIENT (M/M)
.005
ENTER AQUIFER EFFECTIVE BULK DENSITY (KG/CU M)
2390.
ENTER AQUIFER THICKNESS (M)
15.
ENTER AQUIFER WIDTH (M) (PERPENDICULAR TO THE FLOW PATH)
250.
ENTER SATURATED ZONE DISPERSIVITY IN X-DIRECTION
1/10 THE DISTANCE TO THE MONITORING LOCATION IS SUGGESTED'
15.
ENTER SATURATED ZONE DISPERSIVITY IN Y-DIRECTION
1/100 THE DISTANCE TO THE MONITORING LOCATION IS SUGGESTED'
1.5
ENTER SATURATED ZONE DISPERSIVITY IN Z-DIRECTION
1/100 THE DISTANCE TO THE MONITORING LOCATION IS SUGGESTED'
1.5
DO YOU WISH TO ENTER KD VALUES FOR THE
  SATURATED ZONE OR USE DEFAULT VALUES?
  ENTER 0 TO USE DEFAULT VALUES OR
  ENTER 1 TO ENTER VALUES

SELECT DESIRED OPTION FOR DEGRADATION RATES
FOR THE SATURATED ZONE:
(0) USE AEROBIC DECAY RATES
(1) USE ANAEROBIC DECAY RATES
(2) SPECIFY USER DEFINED DECAY RATES

ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF ARSENIC
   4.000E-04
ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF CADMIUM
   1.000E-03
ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF COPPER
   1.000E-02
ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF LEAD
   1.000E-03
ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF MERCURY
   3.000E-04
ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF NICKEL
   2.700E-03
ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF BENZENE
```

Appendix A, Example SLUDGEMAN Run, continued.

```
ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF BENZO(A)PYRENE

ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF BEHP

ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF CHLORDANE

ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF DDT/DDE/DDD

ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF DMN
ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF LINDANE

ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF PCBS

ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF TRICHLOROETHYLENE

ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF TOXAPHENE

ENTER AVERAGE SURFACE WIND VELOCITY (M/S)

ENTER AVERAGE SURFACE AIR TEMPERATURE (DEG CELSIUS)

ENTER AIR-FILLED POROSITY OF COVER SOIL

ENTER TOTAL POROSITY OF COVER SOIL

ENTER COVER THICKNESS DURING ACTIVE PERIOD (M)

ENTER COVER THICKNESS AFTER ACTIVE PERIOD (M)

ENTER CELL LENGTH DURING ACTIVE PERIOD (M)

DO U WISH TO ENTER
MODIFIED HENRY'S LAW CONSTANTS & MOLECULAR WEIGHTS (1)
OR USE DEFAULT VALUES (0)?


A>A:SLUDGFIX.EXE


             PROGRAM:  SLUDGFIX

   THIS PROGRAM ALLOWS THE USER TO MAKE CHANGES TO THE
MODEL INPUT DATA.  THE USER CAN SELECT THE SECTION OF THE
FILE WHERE CHANGES ARE DESIRED RATHER THAN ENTERING A
COMPLETE SET OF NEW DATA.  THE 9 PRIMARY DATA CATEGORIES
ARE:
```

Appendix A, Example SLUDGEMAN Run, continued.

```
          0) EXIT "SLUDGFIX",
          1) CASE NAME,
          2) CONTAMINANT NAME (ADD NEW CONTAMINANTS)
          3) CONTAMINANT CONCENTRATION DATA,
          4) SLUDGE DATA,
          5) SITE DATA,
          6) UNSATURATED ZONE DATA,
          7) SATURATED ZONE DATA,
          8) CONTAMINANT ATTENUATION DATA,
          9) CONTAMINANT DEGRADATION DATA,
         10) BACKGROUND CONCENTRATIONS,
         11) EFFECTS THRESHOLD VALUES,
         12) VAPOR PARAMETERS.

SELECT A CATEGORY
2

EXISTING CONTAMINANT CONCENTRATION DATA:

INDEX  CONTAMINANT            CL, MG/L    CS, MG/KG

    1  ARSENIC                2.0000E+00  1.0000E+00
    2  CADMIUM                2.0000E-01  1.3821E+01
    3  COPPER                 3.7000E+01  1.0000E+04
    4  LEAD                   1.0000E+01  1.1855E+03
    5  MERCURY                6.9000E-01  5.4927E+01
    6  NICKEL                 3.4000E+00  1.0000E+04
    7  BENZENE                3.0918E-02  1.7007E+00
    8  BENZO(A)PYRENE         1.8563E-04  5.9880E+01
    9  BIS(2ETHEX)PTHALATE    8.7769E+00  1.6104E+02
   10  CHLORDANE              1.1700E-01  1.0000E+04
   11  DDT/DDE/DDD            5.9444E-01  5.5297E+01
   12  DIMETHYLNITROSAMINE    3.6084E-04  7.0066E-03
   13  LINDANE                1.7700E+01  1.0000E+04
   14  PCBS                   1.6740E-04  2.6957E+02
   15  TRICHLOROETHYLENE      1.8469E-01  1.8315E+01
   16  TOXAPHENE              3.0896E-02  1.4925E+01

ENTER INDEX NUMBER OF CONTAMINANT WHOSE
CONCENTRATION YOU WANT TO CHANGE OR ENTER 0 TO QUIT
1

EXISTING LIQUID CONCENTRATION OF ARSENIC             IS  2.000E+00
ENTER NEW VALUE
1.

EXISTING SOLID CONCENTRATION OF ARSENIC              IS  1.000E+00
ENTER NEW VALUE
31.965
```

Appendix A, Example SLUDGEMAN Run, continued.

```
EXISTING CONTAMINANT CONCENTRATION DATA:

INDEX  CONTAMINANT           CL, MG/L     CS, MG/KG

    1  ARSENIC              1.0000E+00   3.1965E+01
    2  CADMIUM              2.0000E-01   1.3821E+01
    3  COPPER               3.7000E+01   1.0000E+04
    4  LEAD                 1.0000E+01   1.1855E+03
    5  MERCURY              6.9000E-01   5.4927E+01
    6  NICKEL               3.4000E+00   1.0000E+04
    7  BENZENE              3.0918E-02   1.7007E+00
    8  BENZO(A)PYRENE       1.8563E-04   5.9880E+01
    9  BIS(2ETHEX)PTHALATE 8.7769E+00   1.6104E+02
   10  CHLORDANE            1.1700E-01   1.0000E+04
   11  DDT/DDE/DDD          5.9444E-01   5.5297E+01
   12  DIMETHYLNITROSAMINE 3.6084E-04   7.0066E-03
   13  LINDANE              1.7700E+01   1.0000E+04
   14  PCBS                 1.6740E-04   2.6957E+02
   15  TRICHLOROETHYLENE    1.8469E-01   1.8315E+01
   16  TOXAPHENE            3.0896E-02   1.4925E+01

ENTER INDEX NUMBER OF CONTAMINANT WHOSE
CONCENTRATION YOU WANT TO CHANGE OR ENTER 0 TO QUIT


              PROGRAM:  SLUDGFIX

   THIS PROGRAM ALLOWS THE USER TO MAKE CHANGES TO THE
MODEL INPUT DATA.  THE USER CAN SELECT THE SECTION OF THE

FILE WHERE CHANGES ARE DESIRED RATHER THAN ENTERING A
COMPLETE SET OF NEW DATA.  THE 9 PRIMARY DATA CATEGORIES ARE:


          0) EXIT "SLUDGFIX",
          1) CASE NAME,
          2) CONTAMINANT NAME (ADD NEW CONTAMINANTS)
          3) CONTAMINANT CONCENTRATION DATA,
          4) SLUDGE DATA,
          5) SITE DATA,
          6) UNSATURATED ZONE DATA,
          7) SATURATED ZONE DATA,
          8) CONTAMINANT ATTENUATION DATA,
          9) CONTAMINANT DEGRADATION DATA,
         10) BACKGROUND CONCENTRATIONS,
         11) EFFECTS THRESHOLD VALUES,
         12) VAPOR PARAMETERS.
```

```
SELECT A CATEGORY
6

THE PH (SU) AND EH (MV) CATEGORIES ARE AS FOLLOWS:
         1 - PH 6.0, EH -200
         2 - PH 6.0, EH +150
         3 - PH 6.0, EH +500
         4 - PH 7.0, EH -200
         5 - PH 7.0, EH +150
         6 - PH 7.0, EH +500

THE OLD PH AND EH CATEGORY SELECTED WAS  3

ENTER A NEW PH-EH CATEGORY, OR <CR> TO USE OLD VALUE.
TO BE CONSERVATIVE, SELECT THE LOWER PH VALUE AND THE
HIGHER EH VALUE.


THE SATURATED ZONE MATERIAL TYPES ARE
 1 - CLAY
 2 - SILTY CLAY
 3 - SILTY CLAY LOAM
 4 - CLAY LOAM
 5 - SANDY CLAY LOAM
 6 - SANDY SILT LOAM
 7 - SILTY LOAM
 8 - SANDY LOAM
 9 - LOAMY SAND
10 - SAND
11 - FRACTURED SANDSTONE
12 - FRACTURED LIMESTONE

THE OLD SATURATED ZONE MATERIAL TYPE WAS 10
ENTER A NEW SATURATED ZONE MATERIAL TYPE (OR <CR>)

THE EXISTING VALUE OF SATURATED HYDRAULIC
CONDUCTIVITY FOR THIS MATERIAL IS   1000.000 M/YR

DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y=1, N=CR)
1

ENTER A NEW AQUIFER HYDRAULIC CONDUCTIVITY (M/YR)
2000.

THE OLD SATURATED EFFECTIVE POROSITY =    0.10
ENTER A NEW (OR <CR>) EFFECTIVE POROSITY

THE OLD AQUIFER HYDRAULIC GRADIENT (M/M) =0.5000E-02
ENTER A NEW (OR <CR>) HYDRAULIC GRADIENT
```

```
THE OLD EFFECTIVE BULK DENSITY (KG/CU M) - 2390.00
ENTER A NEW (OR <CR>) EFFECTIVE BULK DENSITY

THE OLD AQUIFER DEPTH (M) -   15.00
ENTER A NEW (OR <CR>) AQUIFER DEPTH (M)

THE OLD AQUIFER WIDTH (M) -    2.50E+02
ENTER A NEW AQUIFER WIDTH (M) (PERPENDICULAR TO THE FLOW PATH)
OR <CR> TO USE PREVIOUS VALUE
1000.

THE OLD LONGITUDINAL DISPERSIVITY (M) -    1.50E+01
ENTER A NEW LONG. DISPERSIVITY (OR <CR>) (M)


THE OLD LATERAL DISPERSIVITY (M) -    1.50E+00
ENTER A NEW LATERAL DISPERSIVITY (OR <CR>) (M)


THE OLD VERTICAL DISPERSIVITY (M) -    1.50E+00
ENTER A NEW VERTICAL DISPERSIVITY (OR <CR>) (M)


NOTICE: CHANGING SATURATED ZONE DATA MAY
        RESULT IN CHANGES TO THE SATURATED
        ZONE KD VALUES.


             PROGRAM:  SLUDGFIX

   THIS PROGRAM ALLOWS THE USER TO MAKE CHANGES TO THE
MODEL INPUT DATA.  THE USER CAN SELECT THE SECTION OF THE
FILE WHERE CHANGES ARE DESIRED RATHER THAN ENTERING A
COMPLETE SET OF NEW DATA.  THE 9 PRIMARY DATA CATEGORIES
ARE:


          0) EXIT "SLUDGFIX",
          1) CASE NAME,
          2) CONTAMINANT NAME (ADD NEW CONTAMINANTS)
          3) CONTAMINANT CONCENTRATION DATA,
          4) SLUDGE DATA,
          5) SITE DATA,
          6) UNSATURATED ZONE DATA,
          7) SATURATED ZONE DATA,
          8) CONTAMINANT ATTENUATION DATA,
          9) CONTAMINANT DEGRADATION DATA,
         10) BACKGROUND CONCENTRATIONS,
         11) EFFECTS THRESHOLD VALUES,
         12) VAPOR PARAMETERS.
```

Appendix A, Example SLUDGEMAN Run, continued.

```
SELECT A CATEGORY
0


A>A:SLUGMAIN.EXE


             PROGRAM:  SLUGMAIN


A>A:CHAIN.EXE

                             PROGRAM:  CHAIN

   THIS PROGRAM CALCULATES THE CHEMICAL CONCENTRATIONS
REACHING THE SATURATED ZONE FOR THOSE CHEMICALS LEAVING
THE LANDFILL AT CONCENTRATIONS ABOVE THE EFFECTS THRESHOLD
VALUES.

***** PROGRAM CHAIN FINISHED *****
FORTRAN STOP



A>A:AT123IN.EXE

                    PROGRAM:  AT123IN

   THIS PROGRAM READS THE OUTPUT FROM "CHAIN" AND DETERMINES
THE APPROPRIATE PERIOD OF TIME AND CONCENTRATION FOR CHEMICAL
INFLUX TO THE SATURATED ZONE.


FORTRAN STOP


A>A:AT123D.EXE

                   PROGRAM:  AT123D

   THIS PROGRAM CALCULATES THE FINAL CONCENTRATION OF ANY
CHEMICALS ENTERING THE SATURATED ZONE ABOVE EFFECTS
THRESHOLD LEVELS.


FORTRAN STOP


A>A:RESULT.EXE
```

Appendix A, Example SLUDGEMAN Run, continued.

```
              PROGRAM:   RESULT

FORTRAN STOP


A>A:ALLCON.EXE


         PROGRAM ALLCON

ALLCON COMBINES THE AQUIFER, VAPOR, AND BACKGROUND
CONCENTRATIONS FOR COMPARISON WITH HEALTH EFFECTS LEVELS

   ###########################################
   #                                         #
   # SEE FILE "ALLCON.OUT" FOR FINAL RESULTS #
   #                                         #
   ###########################################


FORTRAN STOP

A>TYPE ALLCON.OUT

 CONCENTRATIONS IN MG/L, DRY WGHT IN MG/KG

 CHEMICAL     AQUIFER    VAPOR  BCKGROUND    SUM        HEL     DRY WGHT       F
 ---------- --------  -------- --------- --------   --------   --------   --------
 ARSENIC    4.98E-02  .00E+00 4.00E-04  5.02E-02   5.00E-02   3.20E+01   1.00E+00
 CADMIUM    9.09E-03  .00E+00 1.00E-03  1.01E-02   1.00E-02   1.38E+01   1.00E+00
 COPPER     4.23E-01  .00E+00 1.00E-02  4.33E-01   1.30E+00   1.00E+04   1.00E+00
 LEAD       4.91E-02  .00E+00 1.00E-03  5.01E-02   5.00E-02   1.19E+03   1.00E+00
 MERCURY    1.70E-03  .00E+00 3.00E-04  2.00E-03   2.00E-03   5.49E+01   1.00E+00
 NICKEL     5.50E-01  .00E+00 2.70E-03  5.53E-01   1.75E+00   1.00E+04   1.00E+00
 BENZENE    5.00E-03  .00E+00  .00E+00  5.00E-03   5.00E-03   1.70E+00   1.00E+00
 B(A)P      3.00E-05 2.37E-12  .00E+00  3.00E-05   3.00E-05   5.99E+01   1.00E+00
 BEHP       1.68E-05 2.45E-02  .00E+00  2.45E-02   2.45E-02   1.61E+02   1.00E+00
 CHLORDANE  1.12E-06 1.38E-04  .00E+00  1.39E-04   2.10E-04   1.00E+04   1.00E+00
 DDT        3.80E-04 6.40E-04  .00E+00  1.02E-03   1.02E-03   5.53E+01   1.00E+00
 DMN         .00E+00 1.00E-05  .00E+00  1.00E-05   1.00E-05   7.01E-03   1.00E+00
 LINDANE    1.88E-03  .00E+00  .00E+00  1.88E-03   4.00E-03   1.00E+04   1.00E+00
 PCB        2.71E-05 1.84E-05  .00E+00  4.55E-05   4.54E-05   2.70E+02   1.00E+00
 TCE        5.00E-03  .00E+00  .00E+00  5.00E-03   5.00E-03   1.83E+01   1.00E+00
 TOXAPHENE  5.00E-03  .00E+00  .00E+00  5.00E-03   5.00E-03   1.49E+01   1.00E+00

$!COPY SLFIXN.OUT SLUDGFIX.OUT
```

Appendix B. Explanation of the Prompts to the user by SLUDGIN.

The following is a step by step explanation of the prompts from SLUDGIN.

Prompt No.

1 Enter 1 to Create New Data File.
Enter 0 if Data File Already Exists.
Option to create a new input data file (Type 1) or continue the program sequence if a data file already exists (Type 0).

If 0: Program SLUDGIN is automatically terminated and the command sequence proceeds with program SLUDGFIX. This is useful if an input file has been previously created and the user wishes to change only one or two variables in order to see what effect this has on the final chemical concentrations.

If 1: Create a new input data file by responding to the questions.

2 Enter case name or one line description of SLUDGEMAN run.

CONTAMINANT CONCENTRATION DATA

NOTE: For all the following inputs, enter <CR> (carriage return) if an entry of zero is desired.

3 Enter the leachate concentration (mg/l) for arsenic.

4 Enter the dry sludge concentration (mg/kg) for arsenic.

5-34 Enter the leachate concentration (mg/l) followed by the dry sludge concentration (mg/kg) for the remaining 15 contaminants. Enter 0 (or enter <CR>) if the contaminant is not going to be simulated.

SLUDGE DATA

35 Enter sludge moisture content (kg/kg). Units are kg of water per kg of sludge.

36 Enter sludge storage capacity (kg/kg). Units are kg of water per kg of sludge.

37 Enter sludge density (kg/m3).

SITE DATA

38 Enter the net recharge (m/yr). If recharge exceeds aquifer thickness times porosity, then adjust the recharge, aquifer thickness, or aquifer porosity so that the recharge is less

than aquifer thickness times porosity. The product of aquifer thickness and porosity is the water capacity of the aquifer per square meter below the landfill. If the recharge exceeds this aquifer capacity, then the recharge is unrealistically high in relation to this value if steady-state aquifer conditions exist, which is assumed. Therefore, if this condition is encountered, the recharge needs to be reduced.

39 Enter distance from the landfill boundary to the monitoring location/facility boundary (m).

40 Enter the width of the landfill (m) (perpendicular to the flow path between the landfill and the monitoring location).

41 Enter the length of the landfill (m).

42 Enter the height of the fill material (m)

UNSATURATED ZONE DATA

43 Enter an average longitudinal dispersivity value for the entire unsaturated zone. A value of 0.1 times the depth to groundwater from the bottom of the landfill may be reasonable.

44 Enter the number of material layers in the unsaturated zone up to a maximum of 5.

45 Enter the number corresponding to the material type of the first layer. The material types and corresponding numbers are:

1 - Clay
2 - Silty Clay
3 - Silty Clay Loam
4 - Clay Loam
5 - Sandy Clay Loam
6 - Sandy Silt Loam
7 - Silty Loam
8 - Sandy Loam
9 - Loamy Sand
10 - Sand
11 - Fractured Sandstone
12 - Fractured Limestone

46 Enter the thickness of the first layer (m).

NOTE: The program provides a representative value of saturated hydraulic conductivity (m/yr) for the unsaturated zone material type selected. Representative values of hydraulic conductivity for the 12 material types are shown in Appendix S.

47 Option to enter a different value of hydraulic conductivity (Type 1) or to use the representative value (Type 0).

48 If 1 on the previous prompt, enter a new value of hydraulic conductivity (m/yr) for Layer 1.

NOTE: The program provides a representative "B" value (slope of the matrix potential versus moisture content curve) for the unsaturated zone material type selected. Representative "B" values for the 12 material types are shown in Appendix S.

49 Option to enter a different "B value" (Type 1) or to use the representative value (Type 0).

50 If 1 on the previous prompt, enter a new "B value" for Layer 1.

NOTE: The program provides a representative value of effective porosity for the unsaturated zone material type selected. Representative values of effective porosity for the 12 material types simulated are shown in Appendix S.

51 Option to enter a different effective porosity (Type 1) or to use the representative value (Type 0).

52 If 1 on the previous prompt, enter a new value of effective porosity (m3/m3) for Layer 1.

NOTE: The program provides a representative value of effective bulk density for the unsaturated zone material type selected. Representative values of effective bulk density for the 12 material types are shown in Appendix S.

53 Option to enter a different effective bulk density (Type 1) or to use the representative value (Type 0).

54 If 1 on the previous prompt, enter a new value of effective bulk density (kg/m3) for Layer 1.

NOTE: Prompts 45 through 54 are repeated for each unsaturated zone layer.

55 Option to enter distribution coefficients (Kd's) for each contaminant for the unsaturated zone (Type 1) or to use representative Kd values for each contaminant provided by the program (Type 0). Units are 1/kg. See Table 2 for a listing

of the representative distribution coefficients (Kd's) for the 6 metals. Representative Kd's for the organics are derived by multiplying the organic carbon content of the chemical by the fraction of organic carbon in the soil. Representative values of organic carbon content of the 10 organics are shown in Table 3, and representative values of organic carbon fraction for the 12 material types simulated are shown in Table 4.

NOTE: The Kd value selected for each contaminant is representative of the entire unsaturated zone, not individual layers within the zone.

If 1: The program will ask for a Kd value for each contaminant.

56 Option to use aerobic degradation rates supplied by the program (enter a 0), anaerobic degradation rates supplied by the program (enter a 1), or enter user supplied degradation rates (enter a 2). These rates are for the unsaturated zone. Units are 1/yr. See Table 5 for a listing of the program's representative aerobic and anaerobic degradation constants.

NOTE: The degradation rate constant selected for each contaminant is representative of the entire unsaturated zone since it is independent of the material type.

If 2: The program will ask for a degradation rate constant for each contaminant.

SATURATED ZONE DATA

57 Enter the number corresponding to the correct pH (su) and Eh (mv) conditions existing in the saturated zone (aquifer). If the actual values are not listed, select a lower pH value and a higher Eh value to be conservative. The six categories are:

1 - pH 6.0, Eh -200
2 - pH 6.0, Eh +150
3 - pH 6.0, Eh +500
4 - pH 7.0, Eh -200
5 - pH 7.0, Eh +150
6 - pH 7.0, Eh +500

58 Enter the number corresponding to the saturated zone material type. Use the same material type categories used in the unsaturated zone (Prompt 46).

Appendix B, SLUDGIN Prompts, continued.

NOTE: The program provides a representative value of hydraulic conductivity (m/yr) for the saturated zone. Representative values of saturated hydraulic conductivity for the 12 material types simulated are shown in Appendix S.

59 Option to enter a different value of hydraulic conductivity (Type 1) or to use the representative value (Type 0).

60 If 1 on the previous prompt, enter a new value of hydraulic conductivity (m/yr) for the aquifer.

61 Enter the effective porosity (m3/m3) for the saturated zone. If the effective porosity is less than recharge divided by the aquifer thickness, then change the recharge, effective porosity, and/or the aquifer thickness so that the product of the aquifer thickness and effective porosity exceeds the recharge. Otherwise, the aquifer capacity is exceeded by recharge, which is unrealistic under the assumption of steady-state conditions.

62 Enter the hydraulic gradient (m/m) for the saturated zone.

63 Enter the effective bulk density (mg/m3) for the saturated zone.

64 Enter the thickness (m) of the saturated zone.
If the product of the aquifer thickness and effective porosity is less than recharge then change the recharge, effective porosity, and/or the aquifer thickness so that the product of the aquifer thickness and effective porosity exceeds the recharge. Otherwise, the aquifer capacity is exceeded by recharge, which is unrealistic under the assumption of steady-state conditions.

65 Enter the width (m) of the saturated zone (perpendicular to the flow path between the landfill and the monitoring location).

NOTE: An infinite width can be represented as 10 times the landfill width.

66 Enter saturated zone dispersivity in x-direction (m)
1/10 the distance to the monitoring location is the default

67 Enter saturated zone dispersivity in y-direction (m)
1/100 the distance to the monitoring location is the default

68 Enter saturated zone dispersivity in z-direction (m)
1/100 the distance to the monitoring location is the default

69 Option to enter distribution coefficients (Kd's) for each contaminant for the saturated zone (Type 1) or to use representative Kd values for each contaminant provided by the program (Type 0). Units are l/kg. Representative Kd's used by the program for the saturated zone are shown in Tables 2-4. Table 2 shows the representative Kd's used for the 8 metals. The Kd's for the organics are calculated by multiplying the organic carbon content of the chemical by the fraction of organic carbon found in the soil. Representative values of organic carbon content for the 10 organics are shown in Table 3 and representative values of organic carbon fraction for the 12 material types are shown in Table 4. If the program supplies Kd's for the organics, it chooses the appropriate organic carbon content from Table 3 for each organic and multiplies it by the fraction of organic carbon from Table 4

for the soil designated.

If 1: The program will ask for a Kd value for each contaminant.

70 Option to use aerobic degradation rates supplied by the program (enter a 0), anaerobic degradation rates supplied by the program (enter a 1), or enter user supplied degradation rates (enter a 2). These rates are for the saturated zone. Units are 1/yr. See Table 5 for a listing of the program's representative aerobic and anaerobic degradation constants.

If 2: The program will ask for a degradation rate constant for each contaminant.

71-87 Enter a background groundwater concentration (mg/l) for each contaminant. The background concentration is added to the contaminant concentration contributed by the landfill and compared to the effects threshold concentration.

VAPOR PARAMETERS

88 Enter the average surface wind velocity (m/s). The default value is 1 meter per second.

89 Enter the average surface air temperature (degrees Celsius). The default value is 15 degrees Celsius.

90 Enter the air-filled porosity of the soil cover. The default is 0.1.

90 Enter the total porosity of the soil cover. The default is 0.4.

91 Enter the active cell length (m). The default if 8 meters.

Appendix B, SLUDGIN Prompts, continued.

92-123 Enter Modified Henry's Law Constants and Molecular Weights for the 16 chemicals. The default values are shown below and in Appendix S.

Default Henry's Law Constants and Molecular Weights for default Chemicals Analyzed by SLUDGEMAN.

Chemical	Henry's Law Constant	Molecular Weights
Arsenic	0.0	74.92
Cadmium	0.0	51.996
Copper	0.0	63.54
Lead	0.0	207.2
Mercury	0.0	200.59
Nickel	0.0	58.70
Benzene	0.0	78.12
BAP	1.7E-08	252.32
BEHP	0.004625	391.
Chlordane	0.002	410.
DDT/DDE/DDD	0.0017	354.5
DMN	0.02	74.08
Lindane	0.0	290.83
PCB's	0.16	300.
TCE	0.0	132.
Toxaphene	0.0	414.

Appendix C. Example of the SLUDGIN.OUT File.

```
  TEST
 2.0000E+00  1.0000E+01  5.0000E-02
 2.0000E-01  1.3821E+01  1.0000E-02
 3.7000E+01  1.0000E+04  1.3000E+00
 1.0000E+01  1.1855E+03  5.0000E-02
 6.9000E-01  5.4927E+01  2.0000E-03
 3.4000E+00  1.0000E+04  1.7500E+00
 3.0918E-02  1.7007E+00  5.0000E-03
 1.8563E-04  5.9880E+01  3.0000E-05
 8.7769E+00  1.6104E+02  2.4500E-02
 1.1700E-01  1.0000E+04  2.1000E-04
 5.9444E-01  5.5297E+01  1.0200E-03
 3.6084E-04  7.0066E-03  1.0000E-05
 1.7700E+01  1.0000E+04  4.0000E-03
 1.6740E-04  2.6957E+02  4.5400E-05
 1.8469E-01  1.8315E+01  5.0000E-03
 3.0896E-02  1.4925E+01  5.0000E-03
  .8000
  .9000
1025.00
  .2500
1.500E+02
1.000E+02
1.000E+02
3.000E+00
1.000E+00
   1
  10
    10.00
1.000E+04
     4.00
      .39
  1400.00
5.860E+00    .000E+00
1.490E+01    .000E+00
4.190E+01    .000E+00
2.340E+02    .000E+00
3.220E+02    .000E+00
1.220E+01    .000E+00
7.400E-03    .000E+00
5.500E+02    .000E+00
2.000E+05    .000E+00
1.700E+01    .000E+00
5.000E+02    .000E+00
4.000E-06    .000E+00
1.080E-01   1.000E+00
3.200E+01    .000E+00
1.980E-02    .000E+00
9.600E-02    .000E+00
```

Appendix C, SLUDGIN.OUT File continued.

```
    2
 10
  1.000E+03
  1.000E-01
   .5000E-02
  2.390E+03
  1.500E+01
  1.000E+03
  1.500E+01 1.500E+00 1.500E+00
  2.500E+00
  5.860E+00   .000E+00
  1.490E+01   .000E+00
  4.190E+01   .000E+00
  2.340E+02   .000E+00
  3.220E+02   .000E+00
  1.220E+01   .000E+00
   .000E+00   .000E+00
   .000E+00   .000E+00
   .000E+00   .000E+00
   .000E+00  8.430E+00
   .000E+00  9.040E-01
   .000E+00  6.071E+02
   .000E+00  1.000E+00
   .000E+00   .000E+00
   .000E+00  9.040E-01
   .000E+00   .000E+00
  4.000E-04
  1.000E-03
  1.000E-02
  1.000E-03
  3.000E-04
  2.700E-03
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
      1.0
     15.0
      .10        .40
       .3        1.0
      8.0
    .000E+00     74.92
    .000E+00     52.00
    .000E+00     63.54
```

Appendix C, SLUDGIN.OUT File continued.

```
   .000E+00    207.20
   .000E+00    200.59
   .000E+00     58.70
   .000E+00     78.12
  1.700E-08    252.32
  4.625E-03    391.00
  2.000E-03    410.00
  1.700E-03    354.50
  2.000E-02     74.08
   .000E+00    290.83
  1.600E-01    300.00
   .000E+00    132.00
   .000E+00     44.00
```

Appendix D. Example of a SLUDGFIX.OUT File.

```
   TEST
 1.0000E+00  3.1965E+01  5.0000E-02
 2.0000E-01  1.3821E+01  1.0000E-02
 3.7000E+01  1.0000E+04  1.3000E+00
 1.0000E+01  1.1855E+03  5.0000E-02
 6.9000E-01  5.4927E+01  2.0000E-03
 3.4000E+00  1.0000E+04  1.7500E+00
 3.0918E-02  1.7007E+00  5.0000E-03
 1.8563E-04  5.9880E+01  3.0000E-05
 8.7769E+00  1.6104E+02  2.4500E-02
 1.1700E-01  1.0000E+04  2.1000E-04
 5.9444E-01  5.5297E+01  1.0200E-03
 3.6084E-04  7.0066E-03  1.0000E-05
 1.7700E+01  1.0000E+04  4.0000E-03
 1.6740E-04  2.6957E+02  4.5400E-05
 1.8469E-01  1.8315E+01  5.0000E-03
 3.0896E-02  1.4925E+01  5.0000E-03
  .8000
  .9000
1025.00
  .2500
1.500E+02
1.000E+02
1.000E+02
3.000E+00
1.000E+00
   1
  10
    10.00
1.000E+04
     4.00
      .39
  1400.00
5.860E+00   .000E+00
1.490E+01   .000E+00
4.190E+01   .000E+00
2.340E+02   .000E+00
3.220E+02   .000E+00
1.220E+01   .000E+00
7.400E-03   .000E+00
5.500E+02   .000E+00
2.000E+05   .000E+00
1.700E+01   .000E+00
5.000E+02   .000E+00
4.000E-06   .000E+00
1.080E-01  1.000E+00
3.200E+01   .000E+00
1.980E-02   .000E+00
9.600E-02   .000E+00
   3
```

Appendix D, SLUDFIX.OUT File continued.

```
 10
  2.000E+03
  1.000E-01
  .5000E-02
  2.390E+03
  1.500E+01
  1.000E+03
  1.500E+01 1.500E+00 1.500E+00
  2.500E+00
  5.860E+00   .000E+00
  1.490E+01   .000E+00
  4.190E+01   .000E+00
  2.340E+02   .000E+00
  3.220E+02   .000E+00
  1.220E+01   .000E+00
   .000E+00   .000E+00
   .000E+00   .000E+00
   .000E+00   .000E+00
   .000E+00  8.430E+00
   .000E+00  9.040E-01
   .000E+00  6.071E+02
   .000E+00  1.000E+00
   .000E+00   .000E+00
   .000E+00  9.040E-01
   .000E+00   .000E+00
  4.000E-04
  1.000E-03
  1.000E-02
  1.000E-03
  3.000E-04
  2.700E-03
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
   .000E+00
      1.0
     15.0
      .10        .40
       .3        1.0
      8.0
    .000E+00     74.92
    .000E+00     52.00
    .000E+00     63.54
    .000E+00    207.20
```

Appendix D, SLUDGFIX.OUT File continued.

```
     .000E+00     200.59
     .000E+00      58.70
     .000E+00      78.12
    1.700E-08     252.32
    4.625E-03     391.00
    2.000E-03     410.00
    1.700E-03     354.50
    2.000E-02      74.08
     .000E+00     290.83
    1.600E-01     300.00
     .000E+00     132.00
     .000E+00      44.00
```

Appendix E. Example of a SLUDGFIX.DES File

```
                 ****************** SLUDGEMAN ******************
                 *    DRAFT COMMENT VERSION 0.00, DEC., 1987    *
                 *                                              *
                 *           OUTPUT FILE SLUDGFIX.DES           *
                 *        CREATED BY PROGRAM SLUDGFIX.EXE       *
                 *           ON 09-28-88    AT 13:36:22         *
                 *                                              *
                 *     FILE CONTAINS HARD COPY OF CORRECTED     *
                 *                SITE INPUT DATA               *
                 *                                              *
                 ************************************************


 CASE NAME:       TEST


====================================================================
                      CONTAMINANT CONCENTRATION DATA
====================================================================

 CONTAMINANT            CL, MG/L    CS, MG/KG   EFFECTS LEVEL, MG/L
 -----------            --------    ---------   -------------------
 ARSENIC                1.0000E+00  3.1965E+01   5.0000E-02
 CADMIUM                2.0000E-01  1.3821E+01   1.0000E-02
 COPPER                 3.7000E+01  1.0000E+04   1.3000E+00
 LEAD                   1.0000E+01  1.1855E+03   5.0000E-02
 MERCURY                6.9000E-01  5.4927E+01   2.0000E-03
 NICKEL                 3.4000E+00  1.0000E+04   1.7500E+00
 BENZENE                3.0918E-02  1.7007E+00   5.0000E-03
 BENZO(A)PYRENE         1.8563E-04  5.9880E+01   3.0000E-05
 BIS(2ETHEX)PTHALATE    8.7769E+00  1.6104E+02   2.4500E-02
 CHLORDANE              1.1700E-01  1.0000E+04   2.1000E-04
 DDT/DDE/DDD            5.9444E-01  5.5297E+01   1.0200E-03
 DIMETHYLNITROSAMINE    3.6084E-04  7.0066E-03   1.0000E-05
 LINDANE                1.7700E+01  1.0000E+04   4.0000E-03
 PCBS                   1.6740E-04  2.6957E+02   4.5400E-05
 TRICHLOROETHYLENE      1.8469E-01  1.8315E+01   5.0000E-03
 TOXAPHENE              3.0896E-02  1.4925E+01   5.0000E-03

====================================================================
                               SLUDGE DATA
====================================================================

 SLUDGE MOISTURE CONTENT =     .8000 KG/KG
 SLUDGE STORAGE CAPACITY =     .9000 KG/KG
 SLUDGE DENSITY =  1025.00 KG/CU M
```

Appendix E, SLUDGFIX.DES File continued.

```
--------------------------------------------------------------------
                              SITE DATA
--------------------------------------------------------------------

  NET RECHARGE -     .2500 M/YR
  DEPTH TO GROUNDWATER -  10.0000 M
  DISTANCE TO LANDFILL BOUNDARY -     150.00 M
  SITE WIDTH -   100.00 M
  SITE LENGTH -   100.00 M
  FILL HEIGHT -     3.00 M

---------------------------------------------------------------------
                         UNSATURATED ZONE DATA
---------------------------------------------------------------------

  LONGITUDINAL DISPERSIVITY -   1.00E+00

                                                                EFF BULK
                                                     THETA SAT  DENSITY
 MATRIX       THICKNESS, M    K, M/YR        B       CU M/CU M  KG/CU M

 SAND                10.00  1.000E+04      4.00          .39    1400.00
 WEIGHTED AVE                                            .39    1400.00


                                            UNSATURATED
                             UNSATURATED    DEGRADATION RATE
  CONTAMINANT                KD, L/KG       CONSTANT, 1/YR

  ARSENIC                     5.860E+00      .000E+00
  CADMIUM                     1.490E+01      .000E+00
  COPPER                      4.190E+01      .000E+00
  LEAD                        2.340E+02      .000E+00
  MERCURY                     3.220E+02      .000E+00
  NICKEL                      1.220E+01      .000E+00
  BENZENE                     7.400E-03      .000E+00
  BENZO(A)PYRENE              5.500E+02      .000E+00
  BIS(2ETHEX)PTHALATE         2.000E+05      .000E+00
  CHLORDANE                   1.700E+01      .000E+00
  DDT/DDE/DDD                 5.000E+02      .000E+00
  DIMETHYLNITROSAMINE         4.000E-06      .000E+00
  LINDANE                     1.080E-01     1.000E+00
  PCBS                        3.200E+01      .000E+00
  TRICHLOROETHYLENE           1.980E-02      .000E+00
  TOXAPHENE                   9.600E-02      .000E+00
```

Appendix E, SLUDGFIX.DES File continued.

```
-----------------------------------------------------------------
                      SATURATED ZONE DATA
-----------------------------------------------------------------

THE PH / EH CATEGORY IS = 3
GROUNDWATER PH =      6.0 SU
GROUNDWATER EH =   500.0 MV
AQUIFER HYDRAULIC CONDUCTIVITY =  .2000E+04 M/YR
AQUIFER EFFECTIVE POROSITY =       .10 CU M/CU M
GROUNDWATER GRADIENT =  .5000E-02 M/M
AQUIFER EFFECTIVE BULK DENSITY =  2390.00 KG/CU M
AQUIFER THICKNESS =     15.00 M
AQUIFER WIDTH =     1.00E+03 M
LONGITUDINAL DISPERSIVITY =  1.500E+01 SQ M/YR
TRANSVERSE   DISPERSIVITY =  1.500E+00 SQ M/YR
VERTICAL     DISPERSIVITY =  1.500E+00 SQ M/YR
MIXING DEPTH OF AQUIFER =     2.50 M
MIXING DEPTH = RECHARGE / SATURATED EFFECTIVE POROSITY


                                          SATURATED
                           SATURATED      DEGRADATION RATE
CONTAMINANT                KD, L/KG       CONSTANT, 1/YR

ARSENIC                     5.860E+00       .000E+00
CADMIUM                     1.490E+01       .000E+00
COPPER                      4.190E+01       .000E+00
LEAD                        2.340E+02       .000E+00
MERCURY                     3.220E+02       .000E+00
NICKEL                      1.220E+01       .000E+00
BENZENE                      .000E+00       .000E+00
BENZO(A)PYRENE               .000E+00       .000E+00
BIS(2ETHEX)PTHALATE          .000E+00       .000E+00
CHLORDANE                    .000E+00      8.430E+00
DDT/DDE/DDD                  .000E+00      9.040E-01
DIMETHYLNITROSAMINE          .000E+00      6.071E+02
LINDANE                      .000E+00      1.000E+00
PCBS                         .000E+00       .000E+00
TRICHLOROETHYLENE            .000E+00      9.040E-01
TOXAPHENE                    .000E+00       .000E+00
```

Appendix E, SLUDGFIX.DES File continued.

```
BACKGROUND CONCENTRATIONS OF CONTAMINANTS IN GROUNDWATER
CONTAMINANT                CONCENTRATION, MG/L
ARSENIC                    4.00E-04
CADMIUM                    1.00E-03
COPPER                     1.00E-02
LEAD                       1.00E-03
MERCURY                    3.00E-04
NICKEL                     2.70E-03
BENZENE                     .00E+00
BENZO(A)PYRENE              .00E+00
BIS(2ETHEX)PTHALATE         .00E+00
CHLORDANE                   .00E+00
DDT/DDE/DDD                 .00E+00
DIMETHYLNITROSAMINE         .00E+00
LINDANE                     .00E+00
PCBS                        .00E+00
TRICHLOROETHYLENE           .00E+00
TOXAPHENE                   .00E+00

VAPOR PARAMETERS
----------------

AVERAGE SURFACE WIND VEL     1.0 M/S
AVERAGE AIR TEMPERATURE     15.0 DEG C
AIR FILLED COVER POROSITY    .10
TOTAL COVER POROSITY         .40
ACTIVE COVER THICKNESS       .30 M
POST CLOSURE COVER THICK.   1.00 M
ACTIVE CELL LENGTH           8.0 M
SITE LENGTH                100.0 M
SITE WIDTH                 100.0 M

 CHEMICAL        HENRYS LAW  MOL WGHT
---------------- ---------- ---------
ARSENIC           .000E+00     74.92
CADMIUM           .000E+00     52.00
COPPER            .000E+00     63.54
LEAD              .000E+00    207.20
MERCURY           .000E+00    200.59
NICKEL            .000E+00     58.70
BENZENE           .000E+00     78.12
BENZO(A)PYRENE   1.700E-08    252.32
BIS(2ETHEX)PTHAL 4.625E-03    391.00
CHLORDANE        2.000E-03    410.00
DDT/DDE/DDD      1.700E-03    354.50
DIMETHYLNITROSAM 2.000E-02     74.08
LINDANE           .000E+00    290.83
PCBS             1.600E-01    300.00
TRICHLOROETHYLEN  .000E+00    132.00
TOXAPHENE         .000E+00     44.00
```

Appendix F. Sample SLUGMAIN.DES File

```
             ***************** SLUDGEMAN *******************
             *    DRAFT COMMENT VERSION 0.00, DEC., 1987   *
             *                                             *
             *          OUTPUT FILE SLUGMAIN.DES           *
             *       CREATED BY PROGRAM SLUGMAIN.EXE       *
             *         ON 09-28-88   AT 13:36:36           *
             *                                             *
             *        FILE CONTAINS HARD COPY OF THE       *
             *               SLUGMAIN RESULTS              *
             ***********************************************

====================================================================
                           RESULTS OF TIER 1 ANALYSIS
====================================================================

CONTAMINANT           CL, MG/L    ADI, MG/L   STATUS
ARSENIC                .1000E+01   .5000E-01  FAIL
CADMIUM                .2000E+00   .1000E-01  FAIL
COPPER                 .3700E+02   .1300E+01  FAIL
LEAD                   .1000E+02   .5000E-01  FAIL
MERCURY                .6900E+00   .2000E-02  FAIL
NICKEL                 .3400E+01   .1750E+01  FAIL
BENZENE                .3092E-01   .5000E-02  FAIL
BENZO(A)PYRENE         .1856E-03   .3000E-04  FAIL
BIS(2ETHEX)PTHALATE    .8777E+01   .2450E-01  FAIL
CHLORDANE              .1170E+00   .2100E-03  FAIL
DDT/DDE/DDD            .5944E+00   .1020E-02  FAIL
DIMETHYLNITROSAMINE    .3608E-03   .1000E-04  FAIL
LINDANE                .1770E+02   .4000E-02  FAIL
PCBS                   .1674E-03   .4540E-04  FAIL
TRICHLOROETHYLENE      .1847E+00   .5000E-02  FAIL
TOXAPHENE              .3090E-01   .5000E-02  FAIL

TOTAL OF 16 CHEMICALS FAILED TIER 1


====================================================================
                RESULTS OF THE PRELIMINARY TIER 2 ANALYSIS
====================================================================

TOTAL MASS OF SLUDGE -     3075.00 KG/ SQ M
TOTAL MASS OF SLUDGE SOLIDS -      615.00 KG/ SQ M
```

Appendix F, SLUGMAIN.DES File continued.

```
CONTAMINANT          MASS G/ SQ M
ARSENIC                  19.6585
CADMIUM                   8.4999
COPPER                 6150.0000
LEAD                    729.0825
MERCURY                  33.7801
NICKEL                 6150.0000
BENZENE                   1.0459
BENZO(A)PYRENE           36.8262
BIS(2ETHEX)PTHALATE      99.0396
CHLORDANE              6150.0000
DDT/DDE/DDD              34.0077
DIMETHYLNITROSAMINE        .0043
LINDANE                6150.0000
PCBS                    165.7855
TRICHLOROETHYLENE        11.2637
TOXAPHENE                 9.1789

INITIAL SLUDGE WATER HEIGHT PER CUBIC METER -     2.4600 M/CU M
SLUDGE WATER HEIGHT PER CUBIC METER AFTER DRAINAGE -     5.5350 M/CU M
VOLUME OF WATER DRAINED -      .0000 CU M/SQ M


                      ORIGINAL      DRAINED      LEACHABLE       PULSE
CONTAMINANT         MASS, G/SQ M  MASS, G/SQ M  MASS, G/SQ M      TIME
 ARSENIC              1.966E+01     .000E+00     1.966E+01     7.863E+01
 CADMIUM              8.500E+00     .000E+00     8.500E+00     1.700E+02
 COPPER               6.150E+03     .000E+00     6.150E+03     6.649E+02
 LEAD                 7.291E+02     .000E+00     7.291E+02     2.916E+02
 MERCURY              3.378E+01     .000E+00     3.378E+01     1.958E+02
 NICKEL               6.150E+03     .000E+00     6.150E+03     7.235E+03
 BENZENE              1.046E+00     .000E+00     1.046E+00     1.353E+02
 BENZO(A)PYRENE       3.683E+01     .000E+00     3.683E+01     7.935E+05
 BIS(2ETHEX)PTHALAT   9.904E+01     .000E+00     9.904E+01     4.514E+01
 CHLORDANE            6.150E+03     .000E+00     6.150E+03     2.103E+05
 DDT/DDE/DDD          3.401E+01     .000E+00     3.401E+01     2.288E+02
 DIMETHYLNITROSAMIN   4.309E-03     .000E+00     4.309E-03     4.777E+01
 LINDANE              6.150E+03     .000E+00     6.150E+03     1.390E+03
 PCBS                 1.658E+02     .000E+00     1.658E+02     3.961E+06
 TRICHLOROETHYLENE    1.126E+01     .000E+00     1.126E+01     2.439E+02
 TOXAPHENE            9.179E+00     .000E+00     9.179E+00     1.188E+03

MATRIX              S.S. THETA   TOT, YR
SAND                 .1488E+00    .5953E+01
UNSATURATED ZONE WATER TRAVEL TIME (YR) -  5.9533E+00


AVERAGE UNSATURATED WATER VELOCITY -   1.6797E+00 M/YR
AVERAGE UNSATURATED MOISTURE CONTENT -       .1488 CU M/CU M
```

Appendix F, SLUGMAIN.DES File continued.

```
CONTAMINANT           TRAVEL TIME, YR  RETARD FACT.
ARSENIC                  1.3119E+02     2.2036E+01
CADMIUM                  3.2438E+02     5.4487E+01
COPPER                   9.0139E+02     1.5141E+02
LEAD                     5.0067E+03     8.4100E+02
MERCURY                  6.8873E+03     1.1569E+03
NICKEL                   2.6668E+02     4.4795E+01
BENZENE                  6.1114E+00     1.0266E+00
BENZO(A)PYRENE           1.1760E+04     1.9754E+03
BIS(2ETHEX)PTHALATE      4.2741E+06     7.1795E+05
CHLORDANE                3.6926E+02     6.2026E+01
DDT/DDE/DDD              1.0691E+04     1.7959E+03
DIMETHYLNITROSAMINE      5.9534E+00     1.0000E+00
LINDANE                  8.2613E+00     1.3877E+00
PCBS                     6.8982E+02     1.1587E+02
TRICHLOROETHYLENE        6.3764E+00     1.0711E+00
TOXAPHENE                8.0049E+00     1.3446E+00


     TEST


SUMMARY OF INPUT DATA FOR UNSATURATED TRANSPORT CALCULATIONS

ANNUAL RECHARGE =       .2500 M/YR
STEADY STATE MOISTURE CONTENT =       .1488 CU M/CU M
STEADY STATE PORE WATER VELOCITY =     1.6797 M/YR
DEPTH TO WATER TABLE =     10.0000 M

CONTAMINANT       CONC, G/CU M    KD, L/KG      PULSE, YR     LAMDBA, 1/YR
ARSENIC            1.0000E+00    5.8600E+00    7.8634E+01      .0000E+00
CADMIUM            2.0000E-01    1.4900E+01    1.7000E+02      .0000E+00
COPPER             3.7000E+01    4.1900E+01    6.6486E+02      .0000E+00
LEAD               1.0000E+01    2.3400E+02    2.9163E+02      .0000E+00
MERCURY            6.9000E-01    3.2200E+02    1.9583E+02      .0000E+00
NICKEL             3.4000E+00    1.2200E+01    7.2353E+03      .0000E+00
BENZENE            3.0918E-02    7.4000E-03    1.3532E+02      .0000E+00
BENZO(A)PYRENE     1.8563E-04    5.5000E+02    7.9354E+05      .0000E+00
BIS(2ETHEX)PTHA    8.7769E+00    2.0000E+05    4.5136E+01      .0000E+00
CHLORDANE          1.1700E-01    1.7000E+01    2.1026E+05      .0000E+00
DDT/DDE/DDD        5.9444E-01    5.0000E+02    2.2884E+02      .0000E+00
DIMETHYLNITROSAM   3.6084E-04    4.0000E-06    4.7767E+01      .0000E+00
LINDANE            1.7700E+01    1.0800E-01    1.3898E+03     1.0000E+00
PCBS               1.6740E-04    3.2000E+01    3.9614E+06      .0000E+00
TRICHLOROETHYLEN   1.8469E-01    1.9800E-02    2.4395E+02      .0000E+00
TOXAPHENE          3.0896E-02    9.6000E-02    1.1884E+03      .0000E+00
```

Appendix F, SLUGMAIN.DES File continued.

```
CONTAMINANT               CONC, G/CU M   ADI, G/CU M  STATUS
ARSENIC                      .1000E+01     .5000E-01  FAIL
CADMIUM                      .2000E+00     .1000E-01  FAIL
COPPER                       .3700E+02     .1300E+01  FAIL
LEAD                         .1000E+02     .5000E-01  FAIL
MERCURY                      .6900E+00     .2000E-02  FAIL
NICKEL                       .3400E+01     .1750E+01  FAIL
BENZENE                      .3092E-01     .5000E-02  FAIL
BENZO(A)PYRENE               .1856E-03     .3000E-04  FAIL
BIS(2ETHEX)PTHALATE          .8777E+01     .2450E-01  FAIL
CHLORDANE                    .1170E+00     .2100E-03  FAIL
DDT/DDE/DDD                  .5944E+00     .1020E-02  FAIL
DIMETHYLNITROSAMINE          .3608E-03     .1000E-04  FAIL
LINDANE                      .4572E-02     .4000E-02  FAIL
PCBS                         .1674E-03     .4540E-04  FAIL
TRICHLOROETHYLENE            .1847E+00     .5000E-02  FAIL
TOXAPHENE                    .3090E-01     .5000E-02  FAIL



----------------------------------------------------------------------
                          SATURATED ZONE DATA
----------------------------------------------------------------------

AQUIFER VELOCITY =  .1000E+03M/YR
LONGITUDINAL DISPERSION COEFFICIENT =  .1500E+02 SQ M/YR
AQUIFER EFFECTIVE POROSITY =  .1000E+00 CU M/CU M


CONTAMINANT        PULSE, YRS    RETAR FACT   LAMBDA, 1/YR   CONC, G/CU M
ARSENIC            .7863E+02    .1411E+03     .0000E+00      .1000E+01
CADMIUM            .1700E+03    .3571E+03     .0000E+00      .2000E+00
COPPER             .6649E+03    .1002E+04     .0000E+00      .3700E+02
LEAD               .2916E+03    .5594E+04     .0000E+00      .1000E+02
MERCURY            .1958E+03    .7697E+04     .0000E+00      .6900E+00
NICKEL             .7235E+04    .2926E+03     .0000E+00      .3400E+01
BENZENE            .1353E+03    .1000E+01     .0000E+00      .3092E-01
BENZO(A)PYRENE     .7935E+06    .1000E+01     .0000E+00      .1856E-03
BIS(2ETHEX)PTHAL   .4514E+02    .1000E+01     .0000E+00      .8777E+01
CHLORDANE          .2103E+06    .1000E+01     .8430E+01      .1170E+00
DDT/DDE/DDD        .2288E+03    .1000E+01     .9040E+00      .5944E+00
DIMETHYLNITROSAM   .4777E+02    .1000E+01     .6071E+03      .3608E-03
LINDANE            .1390E+04    .1000E+01     .1000E+01      .4572E-02
PCBS               .3961E+07    .1000E+01     .0000E+00      .1674E-03
TRICHLOROETHYLEN   .2439E+03    .1000E+01     .9040E+00      .1847E+00
TOXAPHENE          .1188E+04    .1000E+01     .0000E+00      .3090E-01
```

Appendix G.   Example of Partial CHAIN.INP File.

```
ARSENIC                    CHAIN MODEL INPUT FILE

    1    1    0    0    0    1 1.680E+00 1.680E+00  .000E+00 7.863E+01
2.204E+01 1.100E+00 1.010E+00 1.001E+00  .000E+00 1.100  1.010    1.001
 .000E+00  .000E+00  .000E+00  .000E+00  .000E+00  .0     .0       .0
1.000E+01  .000E+00 1.000E+01  .000E+00 1.508E+01 6.034E+02
1.000E+00  .000E+00  .000E+00  .000E+00  .000E+00  .0     .0       .0
 .000E+00  .000E+00
CADMIUM                    CHAIN MODEL INPUT FILE

    1    1    0    0    0    1 1.680E+00 1.680E+00  .000E+00 1.700E+02
5.449E+01 1.100E+00 1.010E+00 1.001E+00  .000E+00 1.100  1.010  1.001
 .000E+00  .000E+00  .000E+00  .000E+00  .000E+00  .0     .0      .0
1.000E+01  .000E+00 1.000E+01  .000E+00 3.669E+01 1.468E+03
2.000E-01  .000E+00  .000E+00  .000E+00  .000E+00  .0     .0      .0
 .000E+00  .000E+00
COPPER                     CHAIN MODEL INPUT FILE

    1    1    0    0    0    1 1.680E+00 1.680E+00  .000E+00 6.649E+02
1.514E+02 1.100E+00 1.010E+00 1.001E+00  .000E+00 1.100  1.010  1.001
 .000E+00  .000E+00  .000E+00  .000E+00  .000E+00  .0     .0      .0
1.000E+01  .000E+00 1.000E+01  .000E+00 1.068E+02 4.270E+03
3.700E+01  .000E+00  .000E+00  .000E+00  .000E+00  .0     .0      .0
 .000E+00  .000E+00
LEAD                       CHAIN MODEL INPUT FILE

    1    1    0    0    0    1 1.680E+00 1.680E+00  .000E+00 2.916E+02
8.410E+02 1.100E+00 1.010E+00 1.001E+00  .000E+00 1.100 1.010 1.001
 .000E+00  .000E+00  .000E+00  .000E+00  .000E+00  .0     .0      .0
1.000E+01  .000E+00 1.000E+01  .000E+00 5.080E+02 2.032E+04
1.000E+01  .000E+00  .000E+00  .000E+00  .000E+00  .0     .0      .0
 .000E+00  .000E+00
                                        .
                                        .
                                        .
```

Appendix H. Example of Partial CHAIN.OUT File.

```
******************************************************
*                                                    *
*        MULTI-ION SOLUTE TRANSPORT        CHAIN     *
*                                                    *
*        FOURSPECIES                                 *
*        PREFERENTIAL RELEASE                        *
*                                                    *
*        FIRST-TYPE BOUNDARY CONDITION               *
*                                                    *
* ARSENIC                CHAIN MODEL INPUT FILE      *
*                                                    *
******************************************************


     INPUT PARAMETERS
     ----------------

     NS -    1          V -      1.6800          D -       1.6800
     NR -    1          WC -      .0000          TP -  78.63
     NB -    0


TRACER        ZERO          R        DONE          GAMMA         RLAM

   1      .00000D+00    22.040   .00000000     .00000000     .00000000


B(I)-COEFFICIENTS
-----------------

I        B(I)       I       B(I)        I       B(I)        I       B(I)
1  .100000D+01     2  .000000D+00     3  .000000D+00     4  .000000D+00
5  .000000D+00     6  .000000D+00     7  .000000D+00     8  .000000D+00
9  .000000D+00    10  .000000D+00


   DISTANCE        TIME       PORE VOLUME     CONCENTRATION
     (X)           (T)          (VVO)             (1)
  1.000E+01     .000E+00      .000E+00         .000E+00
  1.000E+01    1.508E+01     2.533E+00        4.782E-09
  1.000E+01    3.016E+01     5.067E+00        2.714E-04
  1.000E+01    4.524E+01     7.600E+00        9.652E-03
  1.000E+01    6.032E+01     1.013E+01        5.372E-02
```

Appendix H. Example of Partial CHAIN.OUT File, continued.

```
    1.000E-01     7.540E+01     1.267E+01         1.424E-01
    1.000E-01     9.048E+01     1.520E+01         2.609E-01
    1.000E-01     1.056E+02     1.773E+01         3.884E-01
    1.000E-01     1.206E+02     2.027E+01         5.037E-01
    1.000E-01     1.357E+02     2.280E+01         5.749E-01
    1.000E-01     1.508E+02     2.533E+01         5.833E-01
    1.000E-01     1.659E+02     2.787E+01         5.402E-01
    1.000E-01     1.810E+02     3.040E+01         4.686E-01
    1.000E-01     1.960E+02     3.293E+01         3.882E-01
    1.000E-01     2.111E+02     3.547E+01         3.112E-01
    1.000E-01     2.262E+02     3.800E+01         2.437E-01
    1.000E-01     2.413E+02     4.054E+01         1.877E-01
    1.000E-01     2.564E+02     4.307E+01         1.427E-01
    1.000E-01     2.714E+02     4.560E+01         1.075E-01
    1.000E-01     2.865E+02     4.814E+01         8.036E-02
    1.000E-01     3.016E+02     5.067E+01         5.976E-02
    1.000E-01     3.167E+02     5.320E+01         4.426E-02
    1.000E-01     3.318E+02     5.574E+01         3.267E-02
    1.000E-01     3.468E+02     5.827E+01         2.406E-02
    1.000E-01     3.619E+02     6.080E+01         1.768E-02
    1.000E-01     3.770E+02     6.334E+01         1.298E-02
    1.000E-01     3.921E+02     6.587E+01         9.513E-03
    1.000E-01     4.072E+02     6.840E+01         6.967E-03
    1.000E-01     4.222E+02     7.094E+01         5.100E-03
    1.000E-01     4.373E+02     7.347E+01         3.731E-03
    1.000E-01     4.524E+02     7.600E+01         2.729E-03
    1.000E-01     4.675E+02     7.854E+01         1.995E-03
    1.000E-01     4.826E+02     8.107E+01         1.459E-03
    1.000E-01     4.976E+02     8.360E+01         1.067E-03
    1.000E-01     5.127E+02     8.614E+01         7.799E-04
    1.000E-01     5.278E+02     8.867E+01         5.702E-04
    1.000E-01     5.429E+02     9.120E+01         4.170E-04
    1.000E-01     5.580E+02     9.374E+01         3.050E-04
    1.000E-01     5.730E+02     9.627E+01         2.232E-04
    1.000E-01     5.881E+02     9.880E+01         1.634E-04
    1.000E-01     6.032E+02     1.013E+02         1.196E-04
```

Appendix H. Example of Partial CHAIN.OUT File, continued.

```
************************************************************
*                                                          *
*        MULTI-ION SOLUTE TRANSPORT         CHAIN          *
*                                                          *
*        FOURSPECIES                                       *
*        PREFERENTIAL RELEASE                              *
*                                                          *
*        FIRST-TYPE BOUNDARY CONDITION                     *
*                                                          *
* CADMIUM                 CHAIN MODEL INPUT FILE           *
*                                                          *
************************************************************
                              .
                              .
                              .
```

Appendix I. Example of Partial AT123D.TMP File.

```
ARSENIC                       AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0    1    3
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
 1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 5.860E+00  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 7.863E+01 1.000E+00
    250.00       .25  4.00E-04  1.31E+02
     50.00
       .00
CADMIUM                       AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0    2    3
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
 1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 1.490E+01  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 1.700E+02 2.000E-01
    250.00       .25  1.00E-03  3.24E+02
     50.00
       .00
COPPER                        AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0    3    3
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
 1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 4.190E+01  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 6.649E+02 3.700E+01
    250.00       .25  1.00E-02  9.01E+02
     50.00
       .00
LEAD                          AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0    4    3
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
 1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 2.340E+02  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 2.916E+02 1.000E+01
    250.00       .25  1.00E-03  5.01E+03
     50.00
       .00
MERCURY                       AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0    5    3
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
 1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 3.220E+02  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 1.958E+02 6.900E-01
    250.00       .25  3.00E-04  6.89E+03
     50.00
       .00
NICKEL                        AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0    6    3
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
 1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 1.220E+01  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 7.235E+03 3.400E+00
    250.00       .25  2.70E-03  2.67E+02
     50.00
       .00
```

Appendix I. Example of Partial AT123D.TMP File, continued.

```
BENZENE                       AT123D INPUT FILE
    1    1     1 1000    0    0    0    1    0    1    2    1    1    0    7    3
    15.00   1000.00          .00    100.00          .00    100.00          .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 1.353E+02 3.092E-02
   250.00       .25   .00E+00  6.11E+00
    50.00
      .00
BENZO(A)PYRENE                AT123D INPUT FILE
    1    1     1 1000    0    0    0    1    0    1    2    1    1    0    8    3
    15.00   1000.00          .00    100.00          .00    100.00          .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 7.935E+05 1.856E-04
   250.00       .25   .00E+00  1.18E+04
    50.00
      .00
BIS(2ETHEX)PTHALATE           AT123D INPUT FILE
    1    1     1 1000    0    0    0    1    0    1    2    1    1    0    9    3
    15.00   1000.00          .00    100.00          .00    100.00          .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 4.514E+01 8.777E+00
   250.00       .25   .00E+00  4.27E+06
    50.00
      .00
CHLORDANE                     AT123D INPUT FILE
    1    1     1 1000    0    0    0    1    0    1    2    1    1    0   10    3
    15.00   1000.00          .00    100.00          .00    100.00          .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00 8.430E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 2.103E+05 1.170E-01
   250.00       .25   .00E+00  3.69E+02
    50.00
      .00
DDT/DDE/DDD                   AT123D INPUT FILE
    1    1     1 1000    0    0    0    1    0    1    2    1    1    0   11    3
    15.00   1000.00          .00    100.00          .00    100.00          .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00 9.040E-01 2.390E+00 1.000E+03 1.000E-03  .000E+00 2.288E+02 5.944E-01
   250.00       .25   .00E+00  1.07E+04
    50.00
      .00
DIMETHYLNITROSAMINE           AT123D INPUT FILE
    1    1     1 1000    0    0    0    1    0    1    2    1    1    0   12    3
    15.00   1000.00          .00    100.00          .00    100.00          .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00 6.071E+02 2.390E+00 1.000E+03 1.000E-03  .000E+00 4.777E+01 3.608E-04
   250.00       .25   .00E+00  5.95E+00
    50.00
      .00
```

Appendix I. Example of Partial AT123D.TMP File, continued.

```
LINDANE                    AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0   13    3
    15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00 1.000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 1.390E+03 4.572E-03
   250.00       .25   .00E+00  8.26E+00
    50.00
      .00
PCBS                       AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0   14    3
    15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 3.961E+06 1.674E-04
   250.00       .25   .00E+00  6.90E+02
    50.00
      .00
TRICHLOROETHYLENE          AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0   15    3
    15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00 9.040E-01 2.390E+00 1.000E+03 1.000E-03  .000E+00 2.439E+02 1.847E-01
   250.00       .25   .00E+00  6.38E+00
    50.00
      .00
TOXAPHENE                  AT123D INPUT FILE
    1    1    1 1000    0    0    0    1    0    1    2    1    1    0   16    3
    15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
1.000E-01 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03  .000E+00 1.188E+03 3.090E-02
   250.00       .25   .00E+00  8.00E+00
    50.00
      .00
```

Appendix J. Example AT123D.INP File.

```
ARSENIC
   1    1     1 1000    13    27     1     1     0     1     2     1     1     0
   15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
     .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 5.860E+00  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 1.522E+01 1.522E+02 1.287E+03
  250.00 4.000E-04 1.508E+02
   50.00
     .00
CADMIUM
   1    1     1 1000    16    32     1     1     0     1     2     1     1     0
   15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
     .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 1.490E+01  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 3.274E+01 3.274E+02 2.586E+02
  250.00 1.000E-03 3.302E+02
   50.00
     .00
COPPER
   1    1     1 1000    51   101     5     1     0     1     2     1     1     0
   15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
     .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 4.190E+01  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 1.504E+02 9.382E+03 6.532E+03
  250.00 1.000E-02 1.068E+03
   50.00
     .00
LEAD
   1    1     1 1000    15    31     1     1     0     1     2     1     1     0
   15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
     .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 2.340E+02  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 5.307E+02 5.307E+03 1.368E+03
  250.00 1.000E-03 4.064E+03
   50.00
     .00
MERCURY
   1    1     1 1000    17    34     1     1     0     1     2     1     1     0
   15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
     .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 3.220E+02  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 6.788E+02 6.788E+03 4.953E+01
  250.00 3.000E-04 5.549E+03
   50.00
     .00
NICKEL
   1    1     1 1000    51   101     5     1     0     1     2     1     1     0
   15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
     .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00 1.220E+01  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 4.389E+01 7.233E+03 8.500E+03
  250.00 2.700E-03 1.245E+03
   50.00
     .00
```

Appendix J, AT123D.INP File, continued.

```
BENZENE
    1    1    1 1000   51  101    5    1    0    1    2    1    1    0
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
       .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.352E+02 7.730E+01
    250.00  .000E+00 2.796E+01
     50.00
       .00
BENZO(A)PYRENE
    1    1    1 1000   51  101    5    1    0    1    2    1    1    0
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
       .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.500E+02 4.640E-01
    250.00  .000E+00 6.303E+04
     50.00
       .00
BIS(2ETHEX)PTHALATE
    1    1    1 1000   51  101    5    1    0    1    2    1    1    0
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
       .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
  .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.500E+02 2.592E-01
    250.00  .000E+00 2.992E+06
     50.00
       .00
CHLORDANE
    1    1    1 1000   51  101    5    1    0    1    2    1    1    0
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
       .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
  .000E+00 8.430E+00 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.500E+02 2.925E+02
    250.00  .000E+00 5.293E+03
     50.00
       .00
DDT/DDE/DDD
    1    1    1 1000   51  101    5    1    0    1    2    1    1    0
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
       .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
  .000E+00 9.040E-01 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.500E+02 3.508E+01
    250.00  .000E+00 8.600E+03
     50.00
       .00
DIMETHYLNITROSAMINE
    1    1    1 1000   51  101    5    1    0    1    2    1    1    0
     15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
       .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
  .000E+00 6.071E+02 2.390E+00 1.000E+03 1.000E-03 1.500E-01 4.774E+01 9.020E-01
    250.00  .000E+00 2.506E+01
     50.00
       .00
```

Appendix J, AT123D.INP File, continued.

```
LINDANE
   1    1    1 1000   51  101    5    1    0    1    2    1    1    0
    15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
      .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00 1.000E+00 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.500E+02 2.051E+02
   250.00  .000E+00 3.557E+01
    50.00
      .00
PCBS
   1    1    1 1000   51  101    5    1    0    1    2    1    1    0
    15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
      .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.500E+02 4.185E-01
   250.00  .000E+00 9.910E+04
    50.00
      .00
TRICHLOROETHYLENE
   1    1    1 1000   51  101    5    1    0    1    2    1    1    0
    15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
      .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00 9.040E-01 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.500E+02 4.618E+02
   250.00  .000E+00 2.694E+01
    50.00
      .00
TOXAPHENE
   1    1    1 1000   51  101    5    1    0    1    2    1    1    0
    15.00   1000.00       .00    100.00       .00    100.00       .00      2.50
      .10 2.000E+03 5.000E-03 1.500E+01 1.500E+00 1.500E+00  .000E+00  .000E+00
 .000E+00  .000E+00 2.390E+00 1.000E+03 1.000E-03 1.500E-01 1.500E+02 7.725E+01
   250.00  .000E+00 6.102E+01
    50.00
      .00
```

Appendix K. Example of Partial AT123D.OUT File.

```
   ARSENIC

4.000E-04 BACKGROUND CONCENTRATION (MG/L)
1.508E+02 UNSATURATED ZONE TRAVEL TIME (YRS)

  NO. OF POINTS IN X-DIRECTION ......................     1
  NO. OF POINTS IN Y-DIRECTION ......................     1
  NO. OF POINTS IN Z-DIRECTION ......................     1
  NO. OF ROOTS: NO. OF SERIES TERMS ................ 1000
  NO. OF BEGINNING TIME STEPS .......................    13
  NO. OF ENDING TIME STEP ...........................    27
  NO. OF TIME INTERVALS FOR PRINTED OUT SOLUTION ....     1
  INSTANTANEOUS SOURCE CONTROL = 0 FOR INSTANT SOURCE     1
  SOURCE CONDITION CONTROL = 0 FOR STEADY SOURCE ....     0
  INTERMITTENT OUTPUT CONTROL = 0 NO SUCH OUTPUT ....     1
  CASE CONTROL =1 THERMAL, = 2 FOR CHEMICAL, = 3 RAD      2


  AQUIFER DEPTH, = 0.0 FOR INFINITE DEEP (METERS) ...   .1500E+02
  AQUIFER WIDTH, = 0.0 FOR INFINITE WIDE (METERS) ...   .1000E+04
  BEGIN POINT OF X-SOURCE LOCATION (METERS) .........   .0000E+00
  END POINT OF X-SOURCE LOCATION (METERS) ...........   .1000E+03
  BEGIN POINT OF Y-SOURCE LOCATION (METERS) .........   .0000E+00
  END POINT OF Y-SOURCE LOCATION (METERS) ...........   .1000E+03
  BEGIN POINT OF Z-SOURCE LOCATION (METERS) .........   .0000E+00
  END POINT OF Z-SOURCE LOCATION (METERS) ...........   .2500E+01


  POROSITY ..........................................   .1000E+00
  HYDRAULIC CONDUCTIVITY (METER/HOUR) ...............   .2000E+04
  HYDRAULIC GRADIENT ................................   .5000E-02
  LONGITIDUNAL DESPERSIVITY (METER) .................   .1500E+02
  LATERAL DISPERSIVITY (METER) ......................   .1500E+01
  VERTICAL DISPERSIVITY (METER) .....................   .1500E+01
  DISTRIBUTION COEFFICIENT, KD (M**3/KG) ............   .5860E+01
  HEAT EXCHANGE COEFFICIENT (KCAL/HR-M**2-DEGREE C)..   .0000E+00


  MOLECULAR DIFFUSION MULTIPLY BY TOROSITY (M**2/HR)    .0000E+00
  DECAY CONSTANT (PER HOUR) .........................   .0000E+00
  BULK DENSITY OF THE SOIL (GRAM/CM**3) .............   .2390E+01
  ACCURACY TOLERANCE FOR REACHING STEADY STATE ......   .1000E-02
  DENSITY OF WATER (KG/M**3) ........................   .1000E+04
  TIME INTERVAL SIZE FOR THE DESIRED SOLUTION (HR) ..   .1522E+02
  DISCHARGE TIME (HR) ...............................   .1522E+03
  WASTE RELEASE RATE (KCAL/HR), (KG/HR), OR (CI/HR) .   .1287E+04
```

Appendix K, Example of Partial AT123D.OUT, continued.

```
     RETARDATION FACTOR ................................   .1411E+03
     RETARDED DARCY VELOCITY (M/HR) ...................   .7089E+00
     RETARDED LONGITUDINAL DISPERSION COEF. (M**2/HR) ..   .1063E+02
     RETARDED LATERAL DIEPSERSION COEFFICIENT (M**2/HR)    .1063E+01
     RETARDED VERTICAL DISPERSION COEFFICIENT (M**2/HR).   .1063E+01

   DISTRIBUTION OF CHEMICALS IN PPB AT   .0000E+00 HRS
                   Z -       .00
                                                       X
 Y         250.

50.    .000E+00
   DISTRIBUTION OF CHEMICALS IN PPB AT   .1826E+03 HRS
                   Z -       .00
                                                       X
 Y         250.

50.    .975E+01
   DISTRIBUTION OF CHEMICALS IN PPB AT   .1979E+03 HRS
                   Z -       .00
                                                       X
 Y         250.

50.    .133E+02
   DISTRIBUTION OF CHEMICALS IN PPB AT   .2131E+03 HRS
                   Z -       .00
                                                       X
 Y         250.

50.    .175E+02
   DISTRIBUTION OF CHEMICALS IN PPB AT   .2283E+03 HRS
                   Z -       .00
                                                       X
 Y         250.

50.    .222E+02
   DISTRIBUTION OF CHEMICALS IN PPB AT   .2435E+03 HRS
                   Z -       .00
                                                       X
 Y         250.

50.    .272E+02
   DISTRIBUTION OF CHEMICALS IN PPB AT   .2587E+03 HRS
                   Z -       .00
                                                       X
 Y         250.

50.    .322E+02
```

Appendix K, Example of Partial AT123D.OUT, continued.

```
    DISTRIBUTION OF CHEMICALS IN PPB AT   .2740E+03 HRS
                     Z =         .00
                                                          X
  Y          250.

 50.    .370E+02
    DISTRIBUTION OF CHEMICALS IN PPB AT   .2892E+03 HRS
                     Z =         .00
                                                          X
  Y          250.

 50.    .413E+02
    DISTRIBUTION OF CHEMICALS IN PPB AT   .3044E+03 HRS
                     Z =         .00
                                                          X
  Y          250.

 50.    .448E+02
    DISTRIBUTION OF CHEMICALS IN PPB AT   .3196E+03 HRS
                     Z =         .00
                                                          X
  Y          250.

 50.    .474E+02
    DISTRIBUTION OF CHEMICALS IN PPB AT   .3348E+03 HRS
                     Z =         .00
                                                          X
  Y          250.

 50.    .491E+02
    DISTRIBUTION OF CHEMICALS IN PPB AT   .3501E+03 HRS
                     Z =         .00
                                                          X
  Y          250.

 50.    .498E+02
    DISTRIBUTION OF CHEMICALS IN PPB AT   .3653E+03 HRS
                     Z =         .00
                                                          X
  Y          250.

 50.    .497E+02
    DISTRIBUTION OF CHEMICALS IN PPB AT   .3805E+03 HRS
                     Z =         .00
                                                          X
  Y          250.

 50.    .487E+02
STEADY STATE SOLUTION HAS NOT BEEN REACHED BEFORE FINAL SIMULATING TIME
```

Appendix K, Example of Partial AT123D.OUT, continued.

```
    DISTRIBUTION OF CHEMICALS IN PPB AT    .3957E+03 HRS
                    Z =         .00
                                                          X
  Y          250.

 50.     .471E+02



     CADMIUM
        .
        .
        .
```

Appendix L. Example RESULT.OUT File.

```
    ARSENIC

PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  5.02E-02
EFFECTS THRESHOLD VALUE (MG/L)                       -  5.00E-02
MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  4.98E-02
BACKGROUND CONCENTRATION (MG/L)                      -  4.00E-04

TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  1.51E+02
                                      SATURATED ZONE -  3.50E+02
                TOTAL TRAVEL TIME THROUGH BOTH ZONES -  5.01E+02

-----------------------------------------------------------------


    CADMIUM

PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  1.01E-02
EFFECTS THRESHOLD VALUE (MG/L)                       -  1.00E-02
MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  9.09E-03
BACKGROUND CONCENTRATION (MG/L)                      -  1.00E-03

TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  3.30E+02
                                      SATURATED ZONE -  8.51E+02
                TOTAL TRAVEL TIME THROUGH BOTH ZONES -  1.18E+03

-----------------------------------------------------------------


    COPPER

PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  4.33E-01
EFFECTS THRESHOLD VALUE (MG/L)                       -  1.30E+00
MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  4.23E-01
BACKGROUND CONCENTRATION (MG/L)                      -  1.00E-02

TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  1.07E+03
                                      SATURATED ZONE -  7.52E+03
                TOTAL TRAVEL TIME THROUGH BOTH ZONES -  8.59E+03

-----------------------------------------------------------------
```

Appendix L, RESULT.OUT File, continued.

```
    LEAD

 PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  5.01E-02
 EFFECTS THRESHOLD VALUE (MG/L)                       -  5.00E-02
 MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  4.91E-02
 BACKGROUND CONCENTRATION (MG/L)                      -  1.00E-03

 TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  4.06E+03
                                      SATURATED ZONE -  1.38E+04
                 TOTAL TRAVEL TIME THROUGH BOTH ZONES -  1.79E+04

-----------------------------------------------------------------


    MERCURY

 PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  2.00E-03
 EFFECTS THRESHOLD VALUE (MG/L)                       -  2.00E-03
 MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  1.70E-03
 BACKGROUND CONCENTRATION (MG/L)                      -  3.00E-04

 TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  5.55E+03
                                      SATURATED ZONE -  1.83E+04
                 TOTAL TRAVEL TIME THROUGH BOTH ZONES -  2.39E+04

-----------------------------------------------------------------


    NICKEL

 PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  5.53E-01
 EFFECTS THRESHOLD VALUE (MG/L)                       -  1.75E+00
 MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  5.50E-01
 BACKGROUND CONCENTRATION (MG/L)                      -  2.70E-03

 TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  1.25E+03
                                      SATURATED ZONE -  2.20E+03
                 TOTAL TRAVEL TIME THROUGH BOTH ZONES -  3.44E+03

-----------------------------------------------------------------
```

Appendix L, RESULT.OUT File, continued.

```
     BENZENE

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  5.00E-03
  EFFECTS THRESHOLD VALUE (MG/L)                       -  5.00E-03
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  5.00E-03
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                     UNSATURATED ZONE -  2.80E+01
                                       SATURATED ZONE -  7.50E+00
                     TOTAL TRAVEL TIME THROUGH BOTH ZONES -  3.55E+01

-----------------------------------------------------------------


     BENZO(A)PYRENE

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  3.00E-05
  EFFECTS THRESHOLD VALUE (MG/L)                       -  3.00E-05
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  3.00E-05
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                     UNSATURATED ZONE -  6.30E+04
                                       SATURATED ZONE -  7.50E+00
                     TOTAL TRAVEL TIME THROUGH BOTH ZONES -  6.30E+04

-----------------------------------------------------------------


     BIS(2ETHEX)PTHALATE

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  1.68E-05
  EFFECTS THRESHOLD VALUE (MG/L)                       -  2.45E-02
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  1.68E-05
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                     UNSATURATED ZONE -  2.99E+06
                                       SATURATED ZONE -  7.50E+00
                     TOTAL TRAVEL TIME THROUGH BOTH ZONES -  2.99E+06

-----------------------------------------------------------------
```

Appendix L, RESULT.OUT File, continued.

```
    CHLORDANE

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  1.12E-06
  EFFECTS THRESHOLD VALUE (MG/L)                       -  2.10E-04
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  1.12E-06
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  5.29E+03
                                      SATURATED ZONE -  8.25E+00
                   TOTAL TRAVEL TIME THROUGH BOTH ZONES -  5.30E+03

-----------------------------------------------------------------


    DDT/DDE/DDD

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  3.80E-04
  EFFECTS THRESHOLD VALUE (MG/L)                       -  1.02E-03
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  3.80E-04
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  8.60E+03
                                      SATURATED ZONE -  7.50E+00
                   TOTAL TRAVEL TIME THROUGH BOTH ZONES -  8.61E+03

-----------------------------------------------------------------


    DIMETHYLNITROSAMINE

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -   .00E+00
  EFFECTS THRESHOLD VALUE (MG/L)                       -  1.00E-05
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -   .00E+00
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  2.51E+01
                                      SATURATED ZONE -   .00E+00
                   TOTAL TRAVEL TIME THROUGH BOTH ZONES -  2.51E+01

-----------------------------------------------------------------
```

Appendix L, RESULT.OUT File, continued.

```
     LINDANE

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  1.88E-03
  EFFECTS THRESHOLD VALUE (MG/L)                       -  4.00E-03
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  1.88E-03
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  3.56E+01
                                      SATURATED ZONE -  7.50E+00
                TOTAL TRAVEL TIME THROUGH BOTH ZONES -  4.31E+01

 ----------------------------------------------------------------



     PCBS

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  2.71E-05
  EFFECTS THRESHOLD VALUE (MG/L)                       -  4.54E-05
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  2.71E-05
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  9.91E+04
                                      SATURATED ZONE -  7.50E+00
                TOTAL TRAVEL TIME THROUGH BOTH ZONES -  9.91E+04

 ----------------------------------------------------------------



     TRICHLOROETHYLENE

  PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  5.00E-03
  EFFECTS THRESHOLD VALUE (MG/L)                       -  5.00E-03
  MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  5.00E-03
  BACKGROUND CONCENTRATION (MG/L)                      -   .00E+00

  TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  2.69E+01
                                      SATURATED ZONE -  7.50E+00
                TOTAL TRAVEL TIME THROUGH BOTH ZONES -  3.44E+01

 ----------------------------------------------------------------
```

Appendix L, RESULT.OUT File, continued.

```
    TOXAPHENE

 PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) -  5.00E-03
 EFFECTS THRESHOLD VALUE (MG/L)                      -  5.00E-03
 MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) -  5.00E-03
 BACKGROUND CONCENTRATION (MG/L)                     -   .00E+00

 TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :
                                    UNSATURATED ZONE -  6.10E+01
                                      SATURATED ZONE -  7.50E+00
                 TOTAL TRAVEL TIME THROUGH BOTH ZONES -  6.85E+01

-----------------------------------------------------------------
```

Appendix M. Example ALLCON.OUT File.

```
CONCENTRATIONS IN MG/L, DRY WGHT IN MG/KG

CHEMICAL     AQUIFER   VAPOR    BCKGROUND    SUM       HEL      DRY WGHT      F
----------  --------  --------  ---------  --------  --------  --------  --------
ARSENIC     4.98E-02   .00E+00  4.00E-04   5.02E-02  5.00E-02  3.20E+01  1.00E+00
CADMIUM     9.09E-03   .00E+00  1.00E-03   1.01E-02  1.00E-02  1.38E+01  1.00E+00
COPPER      4.23E-01   .00E+00  1.00E-02   4.33E-01  1.30E+00  1.00E+04  1.00E+00
LEAD        4.91E-02   .00E+00  1.00E-03   5.01E-02  5.00E-02  1.19E+03  1.00E+00
MERCURY     1.70E-03   .00E+00  3.00E-04   2.00E-03  2.00E-03  5.49E+01  1.00E+00
NICKEL      5.50E-01   .00E+00  2.70E-03   5.53E-01  1.75E+00  1.00E+04  1.00E+00
BENZENE     5.00E-03   .00E+00   .00E+00   5.00E-03  5.00E-03  1.70E+00  1.00E+00
B(A)P       3.00E-05  2.37E-12   .00E+00   3.00E-05  3.00E-05  5.99E+01  1.00E+00
BEHP        1.68E-05  2.45E-02   .00E+00   2.45E-02  2.45E-02  1.61E+02  1.00E+00
CHLORDANE   1.12E-06  1.38E-04   .00E+00   1.39E-04  2.10E-04  1.00E+04  1.00E+00
DDT         3.80E-04  6.40E-04   .00E+00   1.02E-03  1.02E-03  5.53E+01  1.00E+00
DMN          .00E+00  1.00E-05   .00E+00   1.00E-05  1.00E-05  7.01E-03  1.00E+00
LINDANE     1.88E-03   .00E+00   .00E+00   1.88E-03  4.00E-03  1.00E+04  1.00E+00
PCB         2.71E-05  1.84E-05   .00E+00   4.55E-05  4.54E-05  2.70E+02  1.00E+00
TCE         5.00E-03   .00E+00   .00E+00   5.00E-03  5.00E-03  1.83E+01  1.00E+00
TOXAPHENE   5.00E-03   .00E+00   .00E+00   5.00E-03  5.00E-03  1.49E+01  1.00E+00
```

Appendix N. Example of SATIT.OUT File.

```
CHEMICAL    AQUIFER  VAPOR C  BCKGRND    SUM       HEL       CS       F
---------- -------- -------- -------- -------- -------- -------- -----
ARSENIC    5.62E-01  .00E+00 4.00E-04 5.63E-01 5.00E-02 3.11E+00 0.088
CADMIUM    1.19E-01  .00E+00 1.00E-03 1.20E-01 1.00E-02 1.22E+00 0.076
COPPER     2.62E+00  .00E+00 1.00E-02 2.63E+00 1.30E+00 4.93E+03 0.493
LEAD       6.91E-01  .00E+00 1.00E-03 6.92E-01 5.00E-02 1.03E+02 0.071
MERCURY    2.33E-02  .00E+00 3.00E-04 2.36E-02 2.00E-03 4.73E+00 0.073
NICKEL     3.40E+00  .00E+00 2.70E-03 3.40E+00 1.75E+00 5.14E+03 0.514
BENZENE    3.09E-02  .00E+00  .00E+00 3.09E-02 5.00E-03 2.75E-01 0.162
B(A)P      1.55E-03 1.98E-11  .00E+00 1.55E-03 3.00E-05 9.69E+00 0.019
BEHP       1.03E-03 2.46E-01  .00E+00 2.47E-01 2.45E-02 1.61E+02 0.099
CHLORDANE  1.17E-01 1.37E-04  .00E+00 1.17E-01 2.10E-04 1.79E+01 0.002
DDT        1.20E-01 5.46E-03  .00E+00 1.25E-01 1.02E-03 3.85E+00 0.008
DMN        3.60E-03 9.98E-05  .00E+00 3.70E-03 1.00E-05 1.89E-04 0.003
LINDANE    8.16E-02  .00E+00  .00E+00 8.16E-02 4.00E-03 4.90E+02 0.049
PCB        1.50E-03 1.65E-04  .00E+00 1.67E-03 4.54E-05 6.57E+01 0.027
TCE        1.26E-01  .00E+00  .00E+00 1.26E-01 5.00E-03 4.06E+00 0.040
TOXAPHENE  2.58E-02  .00E+00  .00E+00 2.58E-02 5.00E-03 3.60E-01 0.194
```

Appendix O. Summary of the Input and Output Data Files for the Programs of the SLUDGEMAN Methodology

Program Name	Input (I) or Output (O) File Name	Description
SLUDGIN	(O) SLUDGIN.DES	Describes input variables
	(O) SLUDGIN.OUT	Contains necessary input values for calculational programs
SLUDGFIX	(I) SLUDGIN.OUT	Basic input file for calculational programs
	(I) SLUDGE.SOR	Contains sorption data from MINTEQ
	(O) SLUDGFIX.OUT	Final input file to calculational Programs, contains any changes made to SLUDGIN.OUT
	(O) SLUDGFIX.DES	Describes values in SLUDGFIX.OUT
	(O) SLUDGN.SOR	Outputs sorption data, unchanged if no chemicals changed
SATM1	(I) SLUDGFIX.OUT	Input data file
	(O) FLAG.FLG	Indicates need to run the unsaturated and saturated zone models
	(O) SATM1.DES	Output file with description of landfill and leachate characteristics
	(O) CHAIN.INP	Primary output data file (input file to the CHAIN model)
	(O) LEACH.FIL	Output file listing chemicals and their leachate concentrations
SLUGMAIN	(I) SLUDGFIX.OUT	Input data file
	(O) FLAG.FLG	Indicates need to run the unsaturated and saturated zone models
	(O) SLUGMAIN.DES	Output file with results of the preliminary Tier 1 and Tier 2 landfill analyses
	(O) CHAIN.INP	Primary output data file (input file to the CHAIN model)
	(O) AT123D.TMP	Secondary output data file (temporary input file to the AT123D model)
CHAIN	(I) FLAG.FLG	Indicates need to run the unsaturated and saturated zone models
	(I) CHAIN.INP	Primary input data file
	(O) CHAIN.OUT	Primary output data file

Appendix O, Input and Output files, continued.

SATIT	(I) SLUDGFIX.OUT	Chemical names, dry weight Concentrations, and background concentrations
	(I) CHAIN.OUT	Unsaturated zone influent Concentrations over time
	(I) LEACH.FIL	Chemical list, leachate Concentrations (for 0 values)
	(O) SATIT.OUT	Results of Class 1 aquifer analysis
	(O) SLFIXN.OUT	New SLUDGIN.OUT file for back-calculating allowable dry weight concentrations
	(O) SATIT.ITR	Indicates progress of convergence
AT123IN	(I) FLAG.FLG	Indicates need to run the unsaturated and saturated zone models
	(I) CHAIN.OUT	Input data file (reads CHAIN program results)
	(I) AT123D.TMP	Input Data file (reads the temporary input file to the AT123D model)
	(I) SLUDGN.SOR	Contains sorption data
	(O) AT123D.INP	Primary output data file (input file to the AT123D model)
AT123D	(I) FLAG.FLG	Indicates need to run the unsaturated and saturated zone programs
	(I) AT123D.INP	Primary input data file
	(O) AT123D.OUT	Primary output data file
RESULT	(I) FLAG.FLG	Indicates whether AT123D was run
	(I) AT123D.OUT	Primary input data file (reads the AT123D program results)
	(O) RESULT.OUT	Peak concentrations from AT123D
ALLCON	(I) RESULT.OUT	Input file containing peak saturated zone outflow concentrations
	(I) SLUDGFIX.OUT	Contains list of chemicals and background concentrations
	(O) ALLCON.OUT	Final result file for Class 2 simulations containing final concentrations and health effects levels in the aquifer
	(O) SLFIXN.OUT	New SLUDGIN.OUT or SLUDGFIX.OUT for iterative mode when back-calculating allowable dry weight concentration.

Appendix P. SLUDGE.BAT Command File.

```
:C SLUDGE
:C
:C SLUDGEMAN BATCH FILE FOR THE IBM PC.
:C THIS BATCH FILE RUNS THE SLUDGEMAN METHODOLOGY FOR PREDICTING
:C CONTAMINANT CONCENTRATIONS AT A LANDFILL FACILITY BOUNDARY.
:C
:C PREPARE INPUT DATA FILE WITH PROGRAM "SLUDGIN".
:C
:START
:C
A:SLUDGIN.EXE
:C
:C MAKE CHANGES TO INPUT DATA FILE WITH PROGRAM "SLUDGFIX".
:C
A:SLUDGFIX.EXE
:C
:C MAKE THE LANDFILL CALCULATIONS AND INITIAL ESTIMATE OF
:C UNSATURATED ZONE CONCENTRATIONS WITH PROGRAM "SLUGMAIN".
:C
A:SLUGMAIN.EXE
:C
:C SIMULATE UNSATURATED ZONE TRANSPORT WITH PROGRAM "CHAIN".
:C
A:CHAIN.EXE
:C
:C PREPARE THE AT123D MODEL INPUT FILE WITH PROGRAM "AT123IN".
:C
A:AT123IN.EXE
:C
:C SIMULATE SATURATED ZONE TRANSPORT WITH PROGRAM "AT123D".
:C
PAUSE INSERT PROGRAM DISK 2 IN DRIVE A:
:C
A:AT123D.EXE
:C
:C FIND PEAK CONCENTRATION IN AT123D.OUT FILE
:C
A:RESULT.EXE
:C
:C CALCULATE VAPOR CONCENTRATION AND WRITE FINAL OUTPUT FILE.
:C
A:ALLCON.EXE
:C
PAUSE INSERT PROGRAM DISK 1 IN DRIVE A:
:C
TYPE ALLCON.OUT
```

Appendix Q. SLUDGE1.BAT Command File.

```
:C SLUDGE1
:C
:C SLUDGEMAN BATCH FILE FOR THE IBM PC.
:C THIS BATCH FILE RUNS THE SLUDGEMAN METHODOLOGY FOR PREDICTING
:C CONTAMINANT CONCENTRATIONS AT A LANDFILL FACILITY BOUNDARY
:C FOR CLASS 1 AQUIFERS.
:C
:C PREPARE INPUT DATA FILE WITH PROGRAM "SLUDGIN".
:C
:START
:C
A:SLUDGIN.EXE
:C
:C MAKE CHANGES TO INPUT DATA FILE WITH PROGRAM "SLUDGFIX".
:C
A:SLUDGFIX.EXE
:C
:C DEL SLUDGIN.OUT
:C COPY SLUDGFIX.OUT SLUDGIN.OUT
:C DEL SLUDGIN.DES
:C COPY SLUDGFIX.DES SLUDGIN.DES
:C
:C MAKE THE LANDFILL CALCULATIONS AND INITIAL ESTIMATE OF
:C UNSATURATED ZONE CONCENTRATIONS WITH PROGRAM "SLUGMAIN".
:C
A:SATM1.EXE
:C
:C SIMULATE UNSATURATED ZONE TRANSPORT WITH PROGRAM "CHAIN".
:C
A:CHAIN.EXE
:C
:C CALCULATE VAPOR CONCENTRATION AND WRITE FINAL OUTPUT FILE.
:C
A:SATIT.EXE
:C
TYPE SATIT.OUT
```

Appendix R. Parameter Default Values.

Table 1. Default Henry's Law Constants and Molecular Weights for default Chemicals Analyzed by SLUDGEMAN.

Chemical	Henry's Law Constant	Henry's Law Reference	Molecular Weight[1]
Arsenic	0.0		74.92
Cadmium	0.0		51.996
Copper	0.0		63.54
Lead	0.0		207.2
Mercury	0.0		200.59
Nickel	0.0		58.70
Benzene	0.0		78.12
BAP	1.7E-08	a	252.32
BEHP	0.004625	b	391.
Chlordane	0.002	c	410.
DDT/DDE/DDD	0.0017	d	354.5
DMN	0.02	e	74.08
Lindane	0.0		290.83
PCB's	0.16	d	300.
TCE	0.0		132.
Toxaphene	0.0		414.

[1] U.S. Environmental Protection Agency. 1985a. Environmental Profiles and Hazard Indices for Constituents of Municipal Sludges. Office of Water, Washington, D.C.

a. Value taken from chemical data base obtained from Battelle. According to the reference in the data base, this value was calculated from vapor pressure and solubility data using the procedure and values in "Critical Review of Henry's Law Constants for Chemicals of Environmental Interest" by Mackay, D. and W. Y. Shiu, 1981.

b. Value taken from Battelle data base. Value calculated from vapor pressure and solubility data using the procedure in "Critical Review of Henry's Law Constants for Chemicals of Environmental Interest" by Mackay, D. and W. Y. Shiu, 1981. The vapor pressure was calculated from boiling points at various pressures using Antoine's equation. The solubility data came from Verschueren, Karel, 1983, "Handbook of Environmental Data on Organic Chemical" (2nd ed.).

c. Value taken from Battelle data base. Value in data base obtained from Hwang, S. T. 1982, "Toxic Emissions from Land Disposal Facilities." Environmental Progress, 1 (1): 46-52.

d. Lyman, W. J., W. F. Reehl and D. H. Rosenblatt, 1982. "Handbook of Chemical Property Estimation Methods". McGraw Hill, San Francisco, CA.

e. Dawson, G. W, C. J. English and S. E. Petty. 1980. "Physical Chemical Properties of Hazardous Waste Constituents." U.S. EPA, Office of Solid Waste, Washington, D.C.

f. Lyman, et al., 1982.

Table 2. Default Values for Some of the Material Characteristics.

Material Type	Hydraulic Conductivities (m/yr)[1]	'B'[2]	Porosity[3]	Bulk Density[4]
Clay	0.032	11.7	0.46	1400.
Silty Clay	0.32	9.9	0.44	1500.
Silty Clay Loam	3.2	7.5	0.42	1500.
Clay Loam	1.0	8.5	0.40	1600.
Sandy Clay Loam	3.2	7.5	0.39	1600.
Sandy Silt Loam	32.0	5.4	0.38	1600.
Silty Loam	32.0	4.8	0.37	1700.
Sandy Loam	100.0	6.3	0.36	1700.
Loamy Sand	320.0	5.6	0.35	1700.
Sand	3200.0	4.0	0.34	1750.
Fractured Sandstone	1.0	4.0	0.30	2620.
Limestone	10.0	4.0	0.25	2390.

[1] Hydraulic Conductivities approximated from ranges given in Freeze, R. Allan and Cherry, John A., Groundwater, 1979, p. 29.

[2] Slope of the log-log plot of hydraulic conductivity versus porosity curve ("B" value) obtained from Battelle Project Management Division 1985. "Technical Guidance Manual for Calculating Time of Travel (TOT) in the Unsaturated Zone". U.S. Environmental Protection Agency.

[3] Freeze and Cherry, Groundewater, 1979, p. 37.

[4] Estimated from bulk density = ps * (1-porosity), with ps an average particle density of 2.65 g/cu. cm. Freeze and Cherry, Groundwater, 1979, p. 337.

Appendix R, Default Values, continued.

Table 3. Default Distribution Coefficients for the 8 Metals.[1]

Distribution Coefficients (l/kg)

Contaminant	Unsaturated		Saturated
	Clay	Sand	
Arsenic	19.4	5.86	5.86
Cadmium	423.0	14.9	14.9
Copper	92.2	41.9	41.9
Lead	597.0	234.0	234.0
Mercury	580.0	322.0	322.0
Nickel	58.6	12.2	12.2

[1] U.S. Environmental Protection Agency. 1985a. Environmental Profiles and Hazard Indices for Constituents of Municipal Sludges. Office of Water, Washington, D.C.

Table 4. Carbon Distribution Coefficient for the 10 Organics. (EPA, 1985a)

Benzene	74.
Benzo(a)pyrene	5,500,000.[1]
Bis(2-ethylhexyl)pthalate	2,000,000,000.[1]
Chlordane	170,000.
DDT	5,000,000.
Dimethylnitrosamine	0.04
Lindane	1080.
PCB's	320,000.
Trichloroethylene	198.
Toxaphene	960.

[1] The values for Benzo(a)pyrene and Bis(2-ethylhexyl)pthalate were obtained from Betsy Southerland, EPA, 1987, after she consulted with people familiar with the leachate characteristics of these organics.

Appendix R, Default Values, continued.

Table 5. Fraction of Organic Carbon for the 12 Soil Types. (Estimated from EPA, 1985a)

Clay	0.01
Silty Clay	0.01
Silty Clay Loam	0.013
Clay Loam	0.01
Sandy Clay Loam	0.005
Sandy Silt Loam	0.005
Silty Loam	0.001
Sandy Loam	0.005
Loamy Sand	0.001
Sand	0.0001
Fractured Sandstone	0.0001
Limestone	0.0001

Table 6. Default Degradation Constants for the 16 Chemicals. (Correspondence with Betsy Southerland, EPA, 1987.)

Contaminant	Anaerobic Decay Constants (1/y) Unsaturated	 Saturated
Arsenic	0.0	0.0
Cadmium	0.0	0.0
Copper	0.0	0.0
Lead	0.0	0.0
Mercury	0.0	0.0
Nickel	0.0	0.0
Benzene	0.0	0.0
Benzo(a)pyrene	0.0	0.0
Bis-2-ethylhexylpthalate	0.0	0.0
Chlordane	0.0	0.0
DDT/DDE/DDD	0.0	8.43
Dimethylnitrosamine	0.0	0.904
Lindane	0.0	607.1
PCB's	1.0	1.0
Trichloroethylene	0.0	0.0
Toxaphene	0.0	0.904
	0.0	0.0

Appendix R, Default Values, continued.

Table 7. Default Values for Vapor Pathway.

1.0 - Surface wind velocity, in meters per second
15.0 - Surface air temperature, degrees Celsius
0.1 - Air-filled porosity of cover soil
0.4 - Total porosity of cover soil
0.3 - Thickness of surface cover during active life (meters)
1.0 - Final thickness of surface cover (meters)
8.0 - Active cell length (meters)

Appendix S. Sorption Data used in AT123IN.

These are the results of the MINTEQ code run by David Brown of the U.S.E.P.A. Environmental Research Laboratory at Athens, Georgia in late 1985 and early 1986. Input and output values are in mg/l (ppm). Output concentrations are for 8 ph/eh values. Eh values are in millivolts.

Number of input values for each of the 6 inorganics:
4,5,4,5,4,4,

Arsenic

Input :	0.06	1.27	2.54	5.06	ph / eh
Output:	1.98E-11	2.29E-11	2.71E-11	4.09E-11	6.0/-200
:	2.4E-04	1.06	2.19	4.43	6.0/+150
:	2.47E-04	1.19	2.46	5.0	6.0/+500
:	5.91E-11	6.83E-11	8.12E-11	1.22E-10	7.0/-200
:	6.07E-02	1.27	2.54	5.06	7.0/+150
:	6.91E-06	1.19	2.46	4.99	7.0/+500
:	5.91E-11	6.83E-11	8.12E-11	1.22E-10	8.1/-206
:	6.07E-02	1.27	2.54	5.06	8.1/+106

Cadmium

Input :	0.01	0.125	0.250	0.499	49.9	ph / eh
Output:	0.0101	0.125	0.250	0.499	49.5	6.0/-200
:	0.01	0.123	0.248	0.498	49.9	6.0/+150
:	0.01	0.123	0.248	0.498	49.9	6.0/+500
:	0.0101	0.125	0.250	0.499	49.5	7.0/-200
:	0.01	0.123	0.248	0.498	49.9	7.0/+150
:	0.01	0.123	0.248	0.498	49.9	7.0/+500
:	0.0083	0.118	0.181	0.266	49.4	8.1/-206
:	0.01	0.125	0.183	0.268	49.4	8.1/+106

Copper

Input :	1.32	32.5	65.4	130.	ph / eh
Output:	1.58E-08	2.0E-07	2.04E-07	2.04E-07	6.0/-200
:	0.162	0.162	0.162	0.162	6.0/+150
:	1.09	3.08	3.15	3.34	6.0/+500
:	7.88E-07	1.9E-06	1.9E-06	1.9E-06	7.0/-200
:	0.15	0.15	0.15	0.15	7.0/+150
:	0.269	0.267	0.265	0.262	7.0/+500
:	7.88E-07	1.9E-06	1.9E-06	1.9E-06	8.1/-206
:	0.15	0.15	0.15	0.15	8.1/+106

Appendix S, Sorption Data, continued.

Lead

						ph / eh
Input :	0.03	0.499	1.0	2.0	10.	
Output:	2.01E-11	2.03E-11	2.05E-11	2.09E-11	4.02E-11	6.0/-200
:	1.36E-07	0.402	0.901	1.9	9.89	6.0/+150
:	1.35E-07	0.402	0.901	1.9	9.89	6.0/+500
:	2.41E-12	2.43E-12	2.46E-12	2.50E-12	2.96E-11	7.0/-200
:	1.06E-07	0.402	0.901	1.9	9.89	7.0/+150
:	1.05E-07	0.402	0.901	1.9	9.67	7.0/+500
:	2.41E-12	2.43E-12	2.46E-12	2.50E-12	2.96E-11	8.1/-206
:	1.06E-07	0.402	0.901	1.9	9.89	8.1/+106

Mercury

					ph / eh
Input :	3.51E-03	7.52E-02	0.15	0.301	
Output:	4.59E-07	4.61E-07	4.61E-07	4.63E-07	6.0/-200
:	1.75E-03	2.43E-02	2.43E-02	2.43E-02	6.0/+150
:	3.41E-03	6.82E-02	0.137	0.243	6.0/+500
:	6.86E-08	6.86E-08	6.86E-08	6.86E-08	7.0/-200
:	1.83E-03	2.43E-02	2.43E-02	2.43E-02	7.0/+150
:	2.13E-04	2.13E-04	2.13E-04	2.13E-04	7.0/+500
:	6.86E-08	6.86E-08	6.86E-08	6.86E-08	8.1/-206
:	1.83E-03	2.43E-02	2.43E-02	2.43E-02	8.1/+106

Nickel

					ph / eh
Input :	0.159	3.75	7.46	15.0	
Output:	4.3E-05	5.65E-05	8.4E-05	3.22E-03	6.0/-200
:	0.16	3.75	7.51	15.0	6.0/+150
:	0.16	3.75	7.51	15.0	6.0/+500
:	4.33E-06	5.69E-06	8.45E-06	3.45E-04	7.0/-200
:	0.16	3.75	7.51	15.0	7.0/+150
:	0.16	3.75	7.51	15.0	7.0/+500
:	4.33E-06	5.69E-06	8.45E-06	3.45E-04	8.1/-206
:	0.16	3.75	7.51	15.0	8.1/+106

Appendix AA - Program SLUDGIN

```
$NOFLOATCALLS
$STORAGE:2
C#######################################################################
C   SLUDGIN.FLX   -   DECEMBER 1987
C
C   AUTHORS: FREDERICK W. BOND
C            CHRIS NEWBILL
C
C   SAME AS SLUDGIN BUT WITHOUT CN AND TKN, AND WITH USER PROMTS
C   FOR UNSAT & SAT ZONE DISPERSIVITIES.
C
C   SLUDGEMAN AUXILARY PROGRAM USED TO CREATE THE PRIMARY AND SECONDARY
C      INPUT DATA FILES.
C           PRIMARY FILE:  SLUDGE.OUT
C           SECONDARY FILE:   SLUDGE.TMP
C   THIS PROGRAM CAN READ THE REQUIRED INPUT DATA FROM THE TERMINAL,
C      OR IT CAN READ A SECONDARY INPUT FILE (SHORT FORM) WHICH HAS
C      ALREADY BEEN CREATED.
C#######################################################################
      INTERFACE TO SUBROUTINE TIME (N,STR)
      CHARACTER*10 STR [NEAR,REFERENCE]
      INTEGER*2 N [VALUE]
      END
      INTERFACE TO SUBROUTINE DATE (N,STR)
      CHARACTER*10 STR [NEAR,REFERENCE]
      INTEGER*2 N [VALUE]
      END
C
      REAL CL(16),CS(16),HC(12),UNHC(5),B(12),THTA(12),EFBD(12),
     #          THIK(5),HEL(16),SAKD(16),SUMUKD(16),UNKD(6,12),UKD(16),
     #          ULAMBD(16),SLAMBD(16),CBACK(16),UB(5),UTHTA(5),UEFBD(5)
C     REAL AULAMB(16),ASLAMB(16)
      REAL KOC(16),FOC(12),H(16),RMW(16)
      INTEGER ITYPE(5),IORGNC(16)
      CHARACTER*4 CHMNAM(5,16),SOILID(4,12)
      CHARACTER*10 CHDATE,CHTIME
      CHARACTER*64 INFILE,CASE
C#######################################################################
C
C   DATA STATEMENTS
C
C#######################################################################
C   16 CONTAMINANTS SIMULATED:
C           6 METALS
C          10 ORGANICS
C--------------------------
      DATA CHMNAM
     # /'ARSE','NIC ','    ','    ','    ',
     #          'CADM','IUM ','    ','    ','    ',
     #          'COPP','ER  ','    ','    ','    ',
     #          'LEAD','    ','    ','    ','    ',
     #          'MERC','URY ','    ','    ','    ',
     #          'NICK','EL  ','    ','    ','    ',
     #          'BENZ','ENE ','    ','    ','    ',
     #          'BENZ','O(A)','PYRE','NE  ','    ',
     #          'BIS(','2ETH','EX)P','THAL','ATE ',
     #          'CHLO','RDAN','E   ','    ','    ',
     #          'DDT/','DDE/','DDD ','    ','    ',
     #          'DIME','THYL','NITR','OSAM','INE ',
     #          'LIND','ANE ','    ','    ','    ',
     #          'PCBS','    ','    ','    ','    ',
     #          'TRIC','HLOR','OETH','YLEN','E   ',
     #          'TOXA','PHEN','E   ','    ','    '/
C-----------------------------------------------
C   FLAG IDENTIFYING METALS (0) OR ORGANICS (1).
C-----------------------------------------------
      DATA IORGNC /0,0,0,0,0,0,1,1,1,1,1,1,1,1,1/
C-------------------------------------------
C   EFFECTS THRESHOLD VALUES (1.E-04 LEVELS)
C-------------------------------------------
      DATA HEL /0.05,0.01,1.3,0.05,0.002,1.75,0.005,
     # 3.0E-05,0.0245,2.1E-04,0.00102,1.E-05,0.004,4.54E-05,
     # 0.005,0.005/
C--------------------------------
C    12 MATERIAL TYPES SIMULATED.
C--------------------------------
      DATA SOILID
     # /'CLAY','    ','    ','    ','SILT','Y CL','AY  ','    ',
     #          'SILT','Y CL','AY L','OAM ','CLAY',' LOA','M   ','    ',
     #          'SAND','Y CL','AY L','OAM ','SAND','Y SI','LT L','OAM ',
     #          'SILT','Y LO','AM  ','    ','SAND','Y LO','AM  ','    ',
     #          'LOAM','Y SA','ND  ','    ','SAND','    ','    ','    ',
     #          'FRAC','. SA','NDST','ONE ','LIME','STON','E   ','    '/
C--------------------------------------------------------------
C   HYDRAULIC CONDUCTIVITIES (M/DAY) FOR THE 12 MATERIAL TYPES.
C--------------------------------------------------------------
      DATA HC /0.032,0.32,3.2,1.0,3.2,32.0,32.0,100,320.0,3200.0,
     #          1.0,10./
C--------------------------------------------------------------------
C   'B' VALUE FOR UNSATURATED ZONE TRAVEL TIME CALCULATION FOR THE 12
C      MATERIAL TYPES.
C   'B' VALUE IS NEGATIVE THE SLOPE OF THE LOG-LOG PLOT OF HEAD VS
C      THETA.
C--------------------------------------------------------------------
          DATA B /11.7,9.9,7.5,8.5,7.5,5.4,4.8,6.3,5.6,4.0,4.0,4.0/
C-----------------------------------------------
```

```
C   EFFECTIVE POROSITY FOR THE 12 MATERIAL TYPES.
C--------------------------------------------------
      DATA THTA/0.46,0.44,0.42,0.4,0.39,0.38,0.37,0.36,0.35,0.34,0.01,
     #          0.10/
C----------------------------------------------------------------
C   EFFECTIVE BULK DENSITY FOR THE 12 MATERIAL TYPES (KG/CU M).
C----------------------------------------------------------------
      DATA EFBD /1400.,1500.,1500.,1600.,1600.,1600.,1700.,1700.,
     #           1700.,1750.,2620.,2390./
C-----------------------------------------------------------------
C   ORGANIC CARBON CONTENT FOR THE 10 ORGANICS (KD = KOC * FOC).
C-----------------------------------------------------------------
      DATA KOC /0.,0.,0.,0.,0.,0.,74.,5.5E+06,2.E+09,1.7E+05,
     #           5.0E+06,0.04,1080.,3.2E+05,198.,960./
C---------------------------------------------------------
C   SATURATED DISTRIBUTION COEFFICIENT FOR THE 7 METALS.
C---------------------------------------------------------
      DATA SAKD /5.86,14.9,41.9,234.0,322.0,12.2,
     #           0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
C---------------------------------------------------------------------
C   FRACTION OF ORGANIC CARBON FOR THE 12 SOIL TYPES (KD = KOC * FOC).
C---------------------------------------------------------------------
      DATA FOC /0.01,0.01,0.013,0.01,0.005,0.005,0.001,0.005,0.001,
     #           0.0001,0.0001,0.0001/
C------------------------------------------------------------------
C   UNSATURATED LAYER DISTRIBUTION COEFFICIENT FOR THE 8 METALS AND
C      THE 12 MATERIAL TYPES (L/KG).
C------------------------------------------------------------------
      DATA UNKD /19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           5.86,14.9,41.9,234.0,322.0,12.2,
     #           5.86,14.9,41.9,234.0,322.0,12.2,
     #           5.86,14.9,41.9,234.0,322.0,12.2,
     #           5.86,14.9,41.9,234.0,322.0,12.2/
C-----------------------------------
C ANAEROBIC UNSATURATED DECAY CONSTANTS
C-----------------------------------
           DATA ULAMBD /0.,0.,0.,0.,0.,0.,
     #          0.,0.,0.,0.,0.,0.,1.0,0.,0.,0./
C-------------------------------------------------------------------
C   AEROBIC UNSATURATED DECAY CONSTANTS FOR THE 16 CONTAMINANTS (1/T).
C-------------------------------------------------------------------
```

```
C     DATA AULAMB /0.,0.,0.,0.,0.,0.,3.90,3.65,0.,0.584,
C    #           0.0198,5.11,0.657,0.1153,0.,0.063/
C-------------------------------------------
C ANAEROBIC SATURATED DECAY CONSTANTS (1/YR)
C-------------------------------------------
      DATA SLAMBD /0.,0.,0.,0.,0.,0.,
     #          0.,0.,0.,8.43,.904,607.1,1.0,0.,0.904,0./
C----------------------------------------------------------------
C AEROBIC SATURATED DECAY CONSTANT FOR THE 16 CONTAMINANTS (1/T).
C----------------------------------------------------------------
C     DATA ASLAMB /0.,0.,0.,0.,0.,0.,
C    #           0.,0.,0.00035,0.,0.0584,0.,0.,0.,0.,0.063/
C---------------------
C HENRY'S LAW CONSTANTS
C---------------------
      DATA H/0.,0.,0.,0.,0.,0.,
     # 0.,1.7E-08,.004625,0.002,0.0017,0.02,0.,0.16,0.,0./
C-----------------
C MOLECULAR WEIGHTS
C-----------------
      DATA RMW/74.92,51.996,63.54,207.2,200.59,58.70,
     # 78.12,252.32,391.,410.,354.5,74.08,290.83,300.,132.,44./
C######################################################################
C
C   BEGIN MAIN PROGRAM
C
C######################################################################
      WRITE (*,1)
1     FORMAT ('      ****************************************'/
     &          '      *          PROGRAM SLUDGIN            *'/
     &          '      *                                     *'/
     &          '      *   WELCOME TO THE SLUDGEMAN COMPUTER *'/
     &          '      *    PROGRAM FOR EVALUATING LANDFILL  *'/
     &          '      * DISPOSAL OF MUNICIPAL SEWAGE SLUDGE *'/
     &          '      *                                     *'/
     &          '      ***************************************'///
     &          '      SLUDGEMAN WILL NOW CREATE AN INPUT DATA'/
     &          '      FILE USING THE DATA FOR YOUR SITE.'/
     &          '      IF YOU HAVE NOT ENTERED DATA FOR THIS'/
     &          '      SITE OR APPLICATION BEFORE, ENTER 1,'/
     &          '      OTHERWISE ENTER 0'/)
2     WRITE (*,3)
3     FORMAT ('      ENTER 1 TO CREATE NEW DATA FILE'/
     &          '      ENTER 0 IF DATA FILE ALREADY EXISTS'//)
      READ (*,4,ERR-2) ANS
4     FORMAT (A)
      IF (ANS .EQ.'0') GOTO 9999
      IF(.NOT.((ANS .NE.'0') .AND. (ANS .NE. '1'))) GO TO 32758
      WRITE (*,5)
5     FORMAT (//'      INVALID SELECTION ')
      GOTO 2
C-----------------------------------------------------------------------
C OPEN 7: "SLUDGE.OUT" -- PRIMARY OUTPUT FILE
C      8: "SLUDGE.TMP" -- SECONDARY OUTPUT FILE FOR MAKING CORRECTIONS
C-----------------------------------------------------------------------
32758 OPEN (7,FILE-'SLUDGIN.DES',STATUS-'NEW')
      OPEN (8,FILE-'SLUDGIN.OUT',STATUS-'NEW')
C-----------------
C READ IN CASE NAME
C-----------------
      WRITE (*,100)
100   FORMAT (/' ENTER THE CASE NAME')
      READ (*,'(A)') CASE
C----------------------------------
C READ IN CONTAMINANT CONCENTRATIONS
C----------------------------------
      DO 32757 I-1,16
110   WRITE (*,120) (CHMNAM(J,I),J-1,5)
120   FORMAT (/' ENTER LEACHATE CONCENTRATION (MG/L) FOR ',5A4)
      READ (*,130,ERR-110) CL(I)
130   FORMAT (F15.0)
140   WRITE (*,150) (CHMNAM(J,I),J-1,5)
150   FORMAT (' ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR ',5A4)
      READ (*,130,ERR-140) CS(I)
32757 CONTINUE
C-------------------
C READ IN SLUDGE DATA
C-------------------
160   WRITE (*,170)
170   FORMAT (/' ENTER SLUDGE MOISTURE CONTENT (KG/KG)')
      READ (*,130,ERR-160) SLMC
180   WRITE (*,190)
190   FORMAT (/' ENTER SLUDGE STORAGE CAPACITY (KG/KG)')
      READ (*,130,ERR-180) SLSC
200   WRITE (*,210)
210   FORMAT (/' ENTER SLUDGE DENSITY (KG/CU M)')
      READ (*,130,ERR-200) SLDN
C-----------------
C READ IN SITE DATA
C-----------------
220   WRITE (*,230)
230   FORMAT (/' ENTER NET RECHARGE (M/YR)')
      READ (*,130,ERR-220) STRC
C-----------------------------------------------------
C DONT'T READ DEPTH TO GROUNDWATER, CALCULATE AS SUM
C OF INDIVIDUAL UNSATURATED LAYERS, TTHIK
```

```
C-----------------------------------------------------
240   WRITE (*,250)
250   FORMAT(/' ENTER DISTANCE FROM LANDFILL BOUNDARY TO MONITORING'
     #          ' LOCATION (M)')
      READ (*,130,ERR=240) STDB
320   WRITE (*,330)
330   FORMAT (/' ENTER LANDFILL WIDTH (M) (PERPENDICULAR TO THE',
     #          ' FLOW PATH)')
      READ (*,130,ERR=320) STWID
340   WRITE (*,350)
350   FORMAT (/' ENTER LANDFILL LENGTH (M)')
      READ (*,130,ERR=340) STLEN
360   WRITE (*,370)
370   FORMAT (/' ENTER FILL HEIGHT (M)')
      READ (*,130,ERR=360) FLHT
C------------------------------
C READ IN UNSATURATED ZONE DATA
C------------------------------
      TTHIK = 0.
      SUMTHT = 0.
      SUMEBD = 0.
      DO 32756 K=1,16
      SUMUKD(K) = 0.
32756 CONTINUE
500   WRITE (*,510)
510   FORMAT (/' ENTER NUMBER OF LAYERS IN UNSATURATED ZONE',
     #          ' (1 TO 5 ALLOWED)')
      READ (*,520,ERR=500) NLAYS
520   FORMAT (I5)
      IF(.NOT.((NLAYS .LT. 1) .OR. (NLAYS .GT. 5))) GO TO 32755
      WRITE (*,530)
530   FORMAT (/' ERROR -- UNALLOWABLE VALUE')
      GOTO 500
C
32755 DO 32754 I=1,NLAYS
540   WRITE (*,550) I
550        FORMAT (/' ENTER MATERIAL TYPE FOR LAYER ',I2,
     #          /'  1 = CLAY'
     #          /'  2 = SILTY CLAY'
     #          /'  3 = SILTY CLAY LOAM'
     #          /'  4 = CLAY LOAM'
     #          /'  5 = SANDY CLAY LOAM'
     #          /'  6 = SANDY SILT LOAM'
     #          /'  7 = SILTY LOAM'
     #          /'  8 = SANDY LOAM'
     #          /'  9 = LOAMY SAND'
     #          /' 10 = SAND'
     #          /' 11 = FRACTURED SANDSTONE'
     #          /' 12 - FRACTURED LIMESTONE')
      READ (*,520,ERR-540) ITYPE(I)
      IF(.NOT.((ITYPE(I) .LT. 1) .OR. (ITYPE(I) .GT. 12))) GO TO 32753
      WRITE (*,510)
      GOTO 540
C
32753 CONTINUE
555   WRITE (*,560) I
560   FORMAT (/' ENTER THICKNESS OF LAYER ',I2,' (M)')
      READ (*,130,ERR-555) THIK(I)
C
      UNHC(I) - HC(ITYPE(I))
      WRITE (*,570) UNHC(I)
570   FORMAT(/' A REASONABLE VALUE OF SATURATED HYDRAULIC CONDUCTIVTY'
     #          /' FOR THIS MATERIAL WOULD BE ',1PE10.3,' M/YR')
580   WRITE (*,890)
      READ (*,520,ERR-580) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32752
590   WRITE (*,600) I
600   FORMAT (/' ENTER A NEW HYDRAULIC CONDUCTIVITY FOR LAYER'I3,
     #          ' (M/YR)')
      READ (*,130,ERR-590) UNHC(I)
C
32752 UB(I) - B(ITYPE(I))
      WRITE (*,610) UB(I)
610   FORMAT(/' A REASONABLE VALUE OF SLOPE OF SOIL CURVE'
     #          /' ("B VALUE") FOR THIS MATERIAL WOULD BE ',F10.4)
620   WRITE (*,890)
      READ (*,520,ERR-620) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32751
630   WRITE (*,640) I
640   FORMAT (/' ENTER A NEW "B VALUE" FOR LAYER ',I3)
      READ (*,130,ERR-630) UB(I)
C
32751 UTHTA(I) - THTA(ITYPE(I))
      WRITE (*,650) UTHTA(I)
650   FORMAT(/' A REASONABLE VALUE OF EFFECTIVE POROSITY'
     #          /' FOR THIS MATERIAL WOULD BE ',F10.4,' CU M/CU M')
660   WRITE (*,890)
      READ (*,520,ERR-660) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32750
670   WRITE (*,680) I
680   FORMAT (/' ENTER A NEW EFFECTIVE POROSITY FOR LAYER'I3,
     #          ' (CU M/CU M)')
      READ (*,130,ERR-670) UTHTA(I)
C
32750 UEFBD(I) - EFBD(ITYPE(I))
      WRITE (*,690) UEFBD(I)
```

```
690    FORMAT(/' A REASONABLE VALUE OF EFFECTIVE BULK DENSITY'
     #          /' FOR THIS MATERIAL WOULD BE ',F10.4,' KG/CU M')
700    WRITE (*,890)
       READ (*,520,ERR=700) IFLG
       IF(.NOT.(IFLG.EQ.1)) GO TO 32749
710    WRITE (*,720) I
720    FORMAT (/' ENTER A NEW EFFECTIVE BULK DENSITY FOR LAYER'I3,
     #          ' (KG/CU M)')
       READ (*,130,ERR=710) UEFBD(I)
C-----------------------------------------------
C   CALCULATE TOTAL THICKNESS,
C      WEIGHTED AVERAGE POROSITY OF ALL LAYERS, AND
C      WEIGHTED AVERAGE BULK DENSITY OF ALL LAYERS.
C-----------------------------------------------
32749 TTHIK = TTHIK + THIK(I)
      SUMTHT = SUMTHT + THIK(I) * UTHTA(I)
      SMEFBD = SMEFBD + THIK(I) * UEFBD(I)
C-------------------------------------------------
C   CALCULATE KD'S FOR THE ORGANICS AS KOC TIMES FOC.
C-------------------------------------------------
      DO 32748 L=1,16
      IF(.NOT.(IORGNC(L) .EQ. 1)) GO TO 32747
      SUMUKD(L) = SUMUKD(L) + (KOC(L) * FOC(ITYPE(I)) * THIK(I))
C----------------------------
C   SET THE KD'S FOR THE METALS.
C----------------------------
32747 IF(.NOT.(IORGNC(L) .EQ. 0)) GO TO 32746
      SUMUKD(L) = SUMUKD(L) + (UNKD(L,ITYPE(I)) * THIK(I))
32746 CONTINUE
32748 CONTINUE
32754 CONTINUE
C-----------------------------------------------------------------
C   CALCULATE THE WEIGHTED AVERAGE POROSITY, BULK DENSITY, AND
C      DISTRIBUTION COEFFICIENT OF ALL UNSATURATED LAYERS BY DIVIDING
C      BY TOTAL THICKNESS.
C-----------------------------------------------------------------
      IF (TTHIK .LE. 0.) GO TO 830
      AVTHTA = SUMTHT / TTHIK
      AVEFBD = SMEFBD / TTHIK
      DO 32744 I=1,16
      UKD(I) = SUMUKD(I) / TTHIK
32744 CONTINUE
C-------------------------------------------------------
C ENTER LONGITUDINAL DISPERSIVITY VALUE FOR UNSATURATED ZONE
C-------------------------------------------------------
730   WRITE (*,740)
740   FORMAT(/' ENTER AN AVERAGE LONGITUDINAL DISPERSIVITY VALUE'/
     # ' FOR THE ENTIRE UNSATURATED ZONE.  <CR> DEFAULTS TO 1/10'/
     # ' THE DEPTH TO GROUNDWATER FROM THE BOTTOM OF THE LANDFILL'/)
      READ (*,130,ERR=730) UDX
      IF (UDX.EQ.0.) UDX = 0.1 * TTHIK
C-------------------------------------------------------
C ENTER UNSATURATED ZONE KD VALUES OR USE DEFAULT VALUES
C-------------------------------------------------------
750   WRITE (*,760)
760   FORMAT (/' DO YOU WISH TO ENTER KD VALUES FOR THE'/
     #          ' UNSATURATED ZONE OR USE DEFAULT VALUES?'/
     #          '   ENTER 0 TO USE DEFAULT VALUES OR'/
     #          '   ENTER 1 TO ENTER VALUES')
      READ (*,520,ERR=750) IKD
      IF(.NOT.(IKD .EQ. 1)) GO TO 32743
      DO 32742 II = 1,16
770   WRITE (*,780) (CHMNAM(J,II),J=1,5)
780   FORMAT (/' ENTER UNSATURATED ZONE KD (L/KG) FOR ',5A4)
      READ (*,130,ERR=770) UKD(II)
32742 CONTINUE
32743 IF(.NOT.((IKD .NE. 0) .AND. (IKD .NE. 1))) GO TO 32741
      WRITE (*,530)
      GOTO 750
C---------------------------------------------------------------
C ENTER UNSATURATED ZONE DEGRADATION RATES OR USE DEFAULT VALUES
C---------------------------------------------------------------
32741 CONTINUE
790   WRITE (*,800)
800   FORMAT (/' SELECT DESIRED OPTION FOR UNSATURATED ZONE'/
     #          ' DEGRADATION RATE CONSTANTS:'/
     #          ' (0) USE ANAEROBIC DECAY RATES'/
     #          ' (1) SPECIFY USER DEFINED DECAY RATES'/)
      READ (*,520,ERR=790) IULAM
      IF (IULAM .NE. 1) GO TO 32740
      DO 32739 II = 1,16
810   WRITE (*,820) (CHMNAM(J,II),J=1,5)
820   FORMAT (/' ENTER UNSATURATED DEGRADATION RATE CONSTANT'/
     #          ' (1/YR) FOR ',5A4)
      READ (*,130,ERR=810) ULAMBD(II)
32739 CONTINUE
32740 IF (IULAM.EQ.0 .OR. IULAM.EQ.1) GO TO 32738
      WRITE (*,530)
      GOTO 790
C----------------------------
C READ IN SATURATED ZONE DATA
C----------------------------
32738 CONTINUE
830   WRITE (*,840)
840   FORMAT (/' SELECT THE APPROPRIATE GROUNDWATER PH (SU)'
     #          /' AND EH (MV) CATEGORY.  IF THE ACTUAL PH AND EH VALUES'
     #         /' ARE NOT LISTED, TO BE CONSERVATIVE, SELECT THE LOWER'
     #         /' PH VALUE AND THE HIGHER EH VALUE'
     #         /'           1 = PH 6.0, EH -200',
     #         /'           2 = PH 6.0, EH +150',
     #         /'           3 = PH 6.0, EH +500',
     #         /'           4 = PH 7.0, EH -200',
     #         /'           5 = PH 7.0, EH +150',
     #         /'           6 = PH 7.0, EH +500',
     #         /'           7 = PH 8.1, EH -206',
     #         /'           8 = PH 8.1, EH +106')
      READ (*,520,ERR=830) IPHEH
      IF((1).NE.(IPHEH)) GO TO 32736
      GWPH = 6.0
      GWEH = -200.
      GO TO 32737
32736 IF((2).NE.(IPHEH)) GO TO 32735
      GWPH = 6.0
      GWEH = 150.
      GO TO 32737
32735 IF((3).NE.(IPHEH)) GO TO 32734
      GWPH = 6.0
      GWEH = 500.
      GO TO 32737
32734 IF((4).NE.(IPHEH)) GO TO 32733
      GWPH = 7.0
      GWEH = -200.
      GO TO 32737
32733 IF((5).NE.(IPHEH)) GO TO 32732
      GWPH = 7.0
      GWEH = 150.
      GO TO 32737
32732 IF((6).NE.(IPHEH)) GO TO 841
      GWPH = 7.0
      GWEH = 500.
      GO TO 32737
841   IF (7.NE.IPHEH) GO TO 842
      GWPH = 8.1
      GWEH = -206.
      GO TO 32737
842   IF (8.NE.IPHEH) GO TO 32731
      GWPH = 8.1
      GWEH = 106.
      GO TO 32737
32731 WRITE (*,530)
      GOTO 830
32737 CONTINUE
850   WRITE (*,860)
860    FORMAT (/' ENTER MATERIAL TYPE FOR SATURATED ZONE',
     #          /'  1 - CLAY'
     #          /'  2 - SILTY CLAY'
     #          /'  3 - SILTY CLAY LOAM'
     #          /'  4 - CLAY LOAM'
     #          /'  5 - SANDY CLAY LOAM'
     #          /'  6 - SANDY SILT LOAM'
     #          /'  7 - SILTY LOAM'
     #          /'  8 - SANDY LOAM'
     #          /'  9 - LOAMY SAND'
     #          /' 10 - SAND'
     #          /' 11 - FRACTURED SANDSTONE'
     #          /' 12 - FRACTURED LIMESTONE')
      READ (*,520,ERR=850) ISATYP
      IF(.NOT.((ISATYP .LT. 1) .OR. (ISATYP .GT. 12))) GO TO 32730
      WRITE (*,530)
      GOTO 850
32730 GWHC = HC(ISATYP)
      WRITE (*,870) GWHC
870   FORMAT (/' A REASONABLE VALUE OF SATURATED HYDRAULIC CONDUCTIVTY'
     #          /' FOR THIS MATERIAL WOULD BE ',F10.3,' M/YR')
880   WRITE (*,890)
890   FORMAT (/' DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y=1, N=0)')
      READ (*,520,ERR=880) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32729
1231  WRITE (*,123)
123   FORMAT (/' ENTER A NEW AQUIFER HYDRAULIC CONDUCTIVITY (M/YR)')
      READ (*,130,ERR=1231) GWHC
32729 CONTINUE
1241  WRITE (*,124)
124   FORMAT (/' ENTER AQUIFER EFFECTIVE POROSITY (CU M/CU M)')
      READ (*,130,ERR=1241) GWEP
1251  WRITE (*,125)
125   FORMAT (/' ENTER AQUIFER HYDRAULIC GRADIENT (M/M)')
      READ (*,130,ERR=1251) GWGR
1261  WRITE (*,126)
126   FORMAT (/' ENTER AQUIFER EFFECTIVE BULK DENSITY (KG/CU M)')
      READ (*,130,ERR=1261) GWEBD
1271  WRITE (*,127)
127   FORMAT(/' ENTER AQUIFER THICKNESS (M)')
      READ (*,130,ERR=1271) AQDEP
1281  WRITE (*,128)
128   FORMAT(/' ENTER AQUIFER WIDTH (M) (PERPENDICULAR TO THE FLOW',
     #          ' PATH)')
      READ (*,130,ERR=1281) AQWID
260   WRITE (*,270)
270   FORMAT(/' ENTER SATURATED ZONE DISPERSIVITY IN X-DIRECTION'/
     # ' <CR> = 1/10 THE DISTANCE TO THE MONITORING LOCATION')
      READ (*,130,ERR=260) DX
      IF (DX.EQ.0.) DX = 0.1 * STDB
280   WRITE (*,290)
290   FORMAT(/' ENTER SATURATED ZONE DISPERSIVITY IN Y-DIRECTION'/
     # ' <CR> = 1/100 THE DISTANCE TO THE MONITORING LOCATION')
      READ (*,130,ERR=280) DY
      IF (DY.EQ.0.) DY = 0.01 * STDB
300   WRITE (*,310)
310   FORMAT(/' ENTER SATURATED ZONE DISPERSIVITY IN Z-DIRECTION'/
     # ' <CR> = 1/100 THE DISTANCE TO THE MONITORING LOCATION')
      READ (*,130,ERR=300) DZ
      IF (DZ.EQ.0.) DZ = 0.01 * STDB
C-----------------------------------------------------
C ENTER SATURATED ZONE KD VALUES OR USE DEFAULT VALUES
C-----------------------------------------------------
1290  WRITE (*,1300)
1300  FORMAT (/' DO YOU WISH TO ENTER KD VALUES FOR THE'/
     #          '   SATURATED ZONE OR USE DEFAULT VALUES?'/
     #          '   ENTER 0 TO USE DEFAULT VALUES OR'/
     #          '   ENTER 1 TO ENTER VALUES')
      READ (*,520,ERR=1290) IKD
      IF(.NOT.(IKD .EQ. 1)) GO TO 32728
      DO 32727 II = 1,16
1311  WRITE (*,131) (CHMNAM(J,II),J=1,5)

131   FORMAT (/' ENTER SATURATED ZONE KD (L/KG) FOR ',5A4)
      READ (*,130,ERR=1311) SAKD(II)
32727 CONTINUE
32728 IF(.NOT.((IKD .NE. 0) .AND. (IKD .NE. 1))) GO TO 32726
      WRITE (*,530)
      GOTO 1290
C------------------------------------------------------------
C ENTER SATURATED ZONE DEGRADATION RATES OR USE DEFAULT VALUES
C------------------------------------------------------------
32726 CONTINUE
132   WRITE (*,133)
133   FORMAT (/' SELECT DESIRED OPTION FOR DEGRADATION RATES'/
     #          ' FOR THE SATURATED ZONE:'/
     #          ' (0) USE ANAEROBIC DECAY RATES'/
     #          ' (1) SPECIFY USER DEFINED DECAY RATES'/)
      READ (*,520,ERR=132) ISLAM
      IF (ISLAM .NE. 1) GO TO 32725
      DO 32724 II = 1,16
1341  WRITE (*,134) (CHMNAM(J,II),J=1,5)
134   FORMAT (/' ENTER SATURATED DEGRADATION RATE CONSTANT'/
     #          ' (1/YR) FOR ',5A4)
      READ (*,130,ERR=1341) SLAMBD(II)
32724 CONTINUE
32725 IF (ISLAM.EQ.0 .OR. ISLAM.EQ.1) GO TO 32723
```

```
      WRITE (*,530)
      GOTO 132
32723 DO 32722 I-1,16
1351  WRITE (*,135) (CHMNAM(J,I),J-1,5)
135   FORMAT(/' ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF ',
     # 5A4)
      READ (*,130,ERR-1351) CBACK(I)
32722 CONTINUE
C-----------------------
C ENTER VAPOR PATHWAY DATA
C-----------------------
      WRITE (*,*)'ENTER AVERAGE SURFACE WIND VELOCITY (M/SEC)'
      READ (*,130) VEL
      IF (VEL.EQ.0.) VEL - 1.
      WRITE (*,*)'ENTER AVERAGE AIR TEMPERATURE (DEGREES CENTIGRADE)'
      READ (*,130) TEMP
      IF (TEMP.EQ.0.) TEMP - 15.
      WRITE (*,*)'ENTER AIR-FILLED POROSITY OF THE COVER SOIL'
      READ (*,130) PA
      IF (PA.EQ.0.) PA - .1
      WRITE (*,*)'ENTER TOTAL POROSITY OF THE COVER SOIL'
      READ (*,130) PT
      IF (PT.EQ.0.) PT - .4
      WRITE (*,*)'ENTER COVER THICKNESS DURING ACTIVE PERIOD (M)'
      READ (*,130) TCA
      IF (TCA.EQ.0.) TCA - .3
      WRITE (*,*)'ENTER COVER THICKNESS DURING POST-CLOSURE PERIOD (M)'
      READ (*,130) TCP
      IF (TCP.EQ.0.) TCP - 1.
      WRITE (*,*)'ENTER ACTIVE CELL LENGTH (M)'
      READ (*,130) XA
      IF (XA.EQ.0.) XA - 8.
      WRITE (*,900)
900   FORMAT(' DO U WISH TO USE DEFAULT VALUES'/
     + ' FOR HENRY''S LAW CONSTANTS AND MOLECULAR WEIGHTS (0)'/
     + ' OR ENTER YOUR OWN (1)?')
      READ (*,520) IH
      IF (IH.EQ.1) THEN
        WRITE (*,910)
910   FORMAT(/' SELECT FOR INPUT:'/
     + '(0) MODIFIED HENRY''S LAW CONSTANTS'/
     + '(1) HENRY''S LAW CONSTANTS')
        READ (*,520) IH
        DO 950 I-1,16
          IF (IH.EQ.0) THEN
            WRITE (*,920) (CHMNAM(J,I),J-1,5)
920         FORMAT(/' ENTER MODIFIED HENRY''S LAW CONSTANT FOR ',5A4)
          ELSE
```

```
              WRITE (*,930) (CHMNAM(J,I),J=1,5)
930           FORMAT(/' ENTER HENRY''S LAW CONSTANT FOR ',5A4)
              READ (*,*) H(I)
              H(I) = H(I)*12188.8/TEMP
            END IF
            WRITE (*,940) (CHMNAM(J,I),J=1,5)
940         FORMAT(' ENTER MOLECULAR WEIGHT FOR '5A4)
            READ (*,*) RMW(I)
950       CONTINUE
        END IF

C960        WRITE (*,965)
C965     FORMAT(/' DO YOU WISH TO BACK-CALCULATE ALLOWABLE INPUT',/
C       + ' (DRY WGHT) CONCENTRATIONS?  1=YES')
C        READ (*,*,ERR=960) ITER
C########################################################################
C
C ECHO INPUT DATA TO OUTPUT FILE
C
C########################################################################
        CALL DATE(10,CHDATE)
        CALL TIME(10,CHTIME)
        WRITE (7,7001)CHDATE,CHTIME
7001    FORMAT (17X,'****************** SLUDGEMAN ******************'/
     #         17X,'*    DRAFT COMMENT VERSION 0.00, DEC., 1987   *'/
     #         17X,'*                                             *'/
     #         17X,'*           OUTPUT FILE SLUDGIN.OUT           *'/
     #         17X,'*        CREATED BY PROGRAM SLUDGIN.EXE       *'/
     #         17X,'*           ON ',A10,' AT ',A10,'       *'/
     #         17X,'*                                             *'/
     #         17X,'*    FILE CONTAINS HARD COPY OF ALL INPUT     *'/
     #         17X,'*    DATA SUPPLIED TO PROGRAM SLUDGIN.EXE     *'/
     #         17X,'*                                             *'/
     #         17X,'***********************************************')
        WRITE (7,7010) CASE
        WRITE (8,8010) CASE
7010    FORMAT (//,1X,'CASE NAME: 'A64,//)
8010    FORMAT (1X,A64)
        WRITE (7,701)
701     FORMAT (1X,79('-'),/,25X,'CONTAMINANT CONCENTRATION DATA',
     #          /,1X,79('-'),//
     # 1X,'CONTAMINANT',11X,'CL, MG/L',4X,'CS, MG/KG',3X'HEL, MG/KG'/)
        DO 32721 I=1,16
        WRITE (7,702) (CHMNAM(J,I),J=1,5),CL(I),CS(I),HEL(I)
        WRITE (8,802) CL(I),CS(I),HEL(I)
702     FORMAT (1X,5A4,1P3E12.4)
802     FORMAT (1X,1P3E12.4)
32721 CONTINUE
```

```
C----------------------
C WRITE OUT SLUDGE DATA
C----------------------
      WRITE (7,703)
703   FORMAT (/1X,79('-'),/,34X,'SLUDGE DATA'/,1X,79('-'),/)
      WRITE (7,704) SLMC
      WRITE (8,804) SLMC
704   FORMAT (' SLUDGE MOISTURE CONTENT - ',F8.4,' KG/KG')
804   FORMAT (1X,F8.4)
      WRITE (7,705) SLSC
      WRITE (8,804) SLSC
705   FORMAT (' SLUDGE STORAGE CAPACITY - ',F8.4,' KG/KG')
      WRITE (7,706) SLDN
      WRITE (8,806) SLDN
706   FORMAT (' SLUDGE DENSITY - ',F8.2,' KG/CU M')
806   FORMAT (1X,F8.2)
      WRITE (7,707)
C--------------------
C WRITE OUT SITE DATA
C--------------------
707   FORMAT (/,1X,79('-'),/,35X,'SITE DATA',/,1X,79('-'),/)
      WRITE (7,708) STRC
      WRITE (8,804) STRC
708   FORMAT (' NET RECHARGE - ',F8.4,' M/YR')
      WRITE (7,709) TTHIK
C     WRITE (8,804) TTHIK
709   FORMAT (' DEPTH TO GROUNDWATER - ',F8.4,' M')
      WRITE (7,7100) STDB
      WRITE (8,812) STDB
7100  FORMAT (' DISTANCE TO LANDFILL BOUNDARY - ',F10.2,' M')
      WRITE (7,724) STWID
      WRITE (8,812) STWID
724   FORMAT (' SITE WIDTH - ',F8.2,' M')
      WRITE (7,725) STLEN
      WRITE (8,812) STLEN
725   FORMAT (' SITE LENGTH - ',F8.2,' M')
      WRITE (7,726) FLHT
      WRITE (8,812) FLHT
726   FORMAT (' FILL HEIGHT - ',F8.2,' M')
      WRITE (8,812) UDX
C------------------------------
C WRITE OUT UNSATURATED ZONE DATA
C------------------------------
      WRITE (7,711) UDX
711   FORMAT (/,1X,79('-'),/,29X,'UNSATURATED ZONE DATA',/,1X,79('-'),
     #          //' AVERAGE LONGITUDINAL DISPERSIVITY - ',1PE10.2//
     #          66X,'EFF BULK'/54X,'THETA SAT',3X,'DENSITY'
     #          /1X,'MATRIX',8X,'THICKNESS, M',4X,'K, M/YR',9X,'B',6X,
     #          'CU M/CU M',3X,'KG/CU M'/)
      WRITE (8,8100) NLAYS
8100  FORMAT(1X,I5)
      DO 32720 I=1,NLAYS
      WRITE (7,712) (SOILID(J,ITYPE(I)),J=1,4),THIK(I),
     #          UNHC(I),UB(I),UTHTA(I),UEFBD(I)
      WRITE (8,8100) ITYPE(I)
      WRITE (8,811) THIK(I)
      WRITE (8,811) UNHC(I)
      WRITE (8,811) UB(I)
      WRITE (8,811) UTHTA(I)
      WRITE (8,811) UEFBD(I)
811   FORMAT (1X,F10.2)
812   FORMAT (1X,1P3E10.3)
712   FORMAT (1X,4A4,2X,F8.2,2X,1PE10.3,2X,0PF8.2,2(2X,F10.2))
32720 CONTINUE
C     IF (TTHIK .GT. 0.)
      WRITE (7,713) AVTHTA,AVEFBD
713   FORMAT (' WEIGHTED AVE',38X,F10.2,2X,F10.2)
      WRITE (7,7131)
7131  FORMAT (//42X,'UNSATURATED'/,26X,'UNSATURATED',5X,
     #          'DEGRADATION RATE',/,1X,'CONTAMINANT',14X,'KD, L/KG',8X,
     #          'CONSTANT, 1/YR',/)
      DO 32717 I=1,16
      WRITE (7,7132) (CHMNAM(J,I),J=1,5),UKD(I),ULAMBD(I)
7132  FORMAT (1X,5A4,2(5X,1PE10.3))
          WRITE (8,813) UKD(I),ULAMBD(I)
813       FORMAT (2(1X,1PE10.3))
32717 CONTINUE
      GO TO 32719
C----------------------------
C WRITE OUT SATURATED ZONE DATA
C----------------------------
32719 WRITE (7,714)
      WRITE (8,1816) IPHEH
714   FORMAT (/1X,79('='),/,30X,'SATURATED ZONE DATA',/,1X,79('='),/)
      WRITE (7,1714) IPHEH
1714  FORMAT (' THE PH / EH CATEGORY IS =',I2)
      WRITE (7,715) GWPH
715   FORMAT (' GROUNDWATER PH = ',F8.4,' SU')
      WRITE (7,716) GWEH
716   FORMAT (' GROUNDWATER EH = ',F8.2,' MV')
          WRITE (7,1716) ISATYP
1716      FORMAT (' AQUIFER MATERIAL TYPE =  ',I2)
          WRITE (8,1816) ISATYP
1816      FORMAT (I5)
     WRITE (7,717) GWHC
     WRITE (8,812) GWHC
```

```
717   FORMAT (' AQUIFER HYDRAULIC CONDUCTIVITY = ',E10.4,' M/YR')
      WRITE (7,718) GWEP
      WRITE (8,812) GWEP
718   FORMAT (' AQUIFER EFFECTIVE POROSITY = ',F8.2,' CU M/CU M')
      WRITE (7,719) GWGR
      WRITE (8,812) GWGR
719   FORMAT (' GROUNDWATER GRADIENT = ',E10.4,' M/M')
      WRITE (7,7200) GWEBD
      WRITE (8,812) GWEBD
7200  FORMAT (' AQUIFER EFFECTIVE BULK DENSITY = ',F8.2,' KG/CU M')
      WRITE (7,1724) AQDEP
      WRITE (8,812) AQDEP
1724  FORMAT (' AQUIFER THICKNESS = ',F8.2,' M')
      WRITE (7,1725) AQWID
      WRITE (8,812) AQWID
1725  FORMAT (' AQUIFER WIDTH = ',1PE12.2,' M')
      WRITE (7,721) DX,DY,DZ
      WRITE (8,812) DX,DY,DZ
721   FORMAT(
     #          ' LONGITUDINAL DISPERSIVITY = ',1PE10.3' M/YR'/
     #          ' TRANSVERSE   DISPERSIVITY = ',E10.3' M/YR'/
     #          ' VERTICAL     DISPERSIVITY = ',E10.3' M/YR')
C-------------------------------------------------------------
C   SET THE MIXING DEPTH OF THE SATURATED LAYER TO THE DEPTH OF
C      PENETRATION OF THE RECHARGE.  THIS IS CALCULATED AS THE
C      RECHARGE DIVIDED BY SATURATED EFFECTIVE POROSITY.
C-------------------------------------------------------------
      DEPTH = STRC / GWEP
      WRITE (7,727) DEPTH
727   FORMAT (' MIXING DEPTH OF AQUIFER = ',F8.2,' M'
     #          /' MIXING DEPTH = RECHARGE / SATURATED EFFECTIVE POROSITY')
      WRITE (8,812) DEPTH
      WRITE (7,7270)
7270  FORMAT (//41X,'SATURATED'/,26X,'SATURATED',6X,
     #          'DEGRADATION RATE',/,1X,'CONTAMINANT',14X,'KD, L/KG',7X,
     #          'CONSTANT, 1/YR'/)

      DO 32713 II=1,16
      WRITE (7,7271) (CHMNAM(J,II),J=1,5),SAKD(II),SLAMBD(II)
7271  FORMAT (1X,5A4,2(5X,1PE10.3))
          WRITE (8,813) SAKD(II),SLAMBD(II)
32713 CONTINUE
      WRITE (7,728)
728   FORMAT (//' BACKGROUND CONCENTRATIONS OF CONTAMINANTS',
     # ' IN GROUNDWATER'/
     #          ' CONTAMINANT',16X,'CONCENTRATION, MG/L')
      DO 32711 I=1,16
      WRITE (7,729) (CHMNAM(J,I),J=1,5),CBACK(I)
```

```
729   FORMAT (1X,5A4,5X,1PE10.2)
      WRITE (8,812) CBACK(I)
32711 CONTINUE
C-----------------------------
C WRITE VAPOR PATHWAY PARAMETERS
C-----------------------------
      WRITE (7,1100) VEL,TEMP,PA,PT,TCA,TCP,XA,STLEN,STWID,
     + ((CHMNAM(J,I),J=1,5),H(I),RMW(I),I=1,16)
1100  FORMAT(/' VAPOR PATHWAY PARAMETERS'/1X,24('-')//
     + ' AVERAGE SURFACE WIND VELOCITY     =',F10.1' M/S'/
     + ' AVERAGE AIR TEMPERATURE           =',F10.1' DEG C'/
     + ' AIR-FILLED POROSITY OF COVER SOIL =',F10.2/
     + ' TOTAL POROSITY OF COVER SOIL      =',F10.2/
     + ' COVER THICKNESS DURING ACTIVITY   =',F10.2' METERS'/
     + ' COVER THICKNESS AFTER CLOSURE     =',F10.2' METERS'/
     + ' CELL LENGTH DURING ACTIVE PERIOD  =',F10.2' METERS'/
     + ' SITE LENGTH                       =',F10.2' METERS'/
     + ' SITE WIDTH                        =',F10.2' METERS'//
     + 3X'CHEMICAL'11X'HENRY''S LAW  MOL WEIGHT'/
     + 1X,20('-'),1X,11('-'),2X,10('-')/(1X,5A4,1PE12.3,0PF10.2))
      WRITE (8,1120) VEL,TEMP,PA,PT,TCA,TCP,XA,(H(I),RMW(I),I=1,16)
1120  FORMAT(2(F10.2/),2(2F10.2/),F10.2/,(1PE12.3,0PF10.2))
C      WRITE (8,1130) ITER
C1130  FORMAT(I5)
999   CLOSE (7)
      CLOSE (2)
9999  END
$NOFLOATCALLS
$STORAGE:2
C######################################################################
C   SLUDGIN.FLX   -   DECEMBER 1987
C
C   AUTHORS: FREDERICK W. BOND
C            CHRIS NEWBILL
C
C   SAME AS SLUDGIN BUT WITHOUT CN AND TKN, AND WITH USER PROMTS
C   FOR UNSAT & SAT ZONE DISPERSIVITIES.
C
C   SLUDGEMAN AUXILARY PROGRAM USED TO CREATE THE PRIMARY AND SECONDARY
C      INPUT DATA FILES.
C           PRIMARY FILE:  SLUDGE.OUT
C           SECONDARY FILE:   SLUDGE.TMP
C   THIS PROGRAM CAN READ THE REQUIRED INPUT DATA FROM THE TERMINAL,
C      OR IT CAN READ A SECONDARY INPUT FILE (SHORT FORM) WHICH HAS
C      ALREADY BEEN CREATED.
C######################################################################
      INTERFACE TO SUBROUTINE TIME (N,STR)
      CHARACTER*10 STR [NEAR,REFERENCE]
      INTEGER*2 N [VALUE]
      END
      INTERFACE TO SUBROUTINE DATE (N,STR)
      CHARACTER*10 STR [NEAR,REFERENCE]
      INTEGER*2 N [VALUE]
      END
C
      REAL CL(16),CS(16),HC(12),UNHC(5),B(12),THTA(12),EFBD(12),
     #          THIK(5),HEL(16),SAKD(16),SUMUKD(16),UNKD(6,12),UKD(16),
     #          ULAMBD(16),SLAMBD(16),CBACK(16),UB(5),UTHTA(5),UEFBD(5)
C     REAL AULAMB(16),ASLAMB(16)
      REAL KOC(16),FOC(12),H(16),RMW(16)
      INTEGER ITYPE(5),IORGNC(16)
      CHARACTER*4 CHMNAM(5,16),SOILID(4,12)
      CHARACTER*10 CHDATE,CHTIME
      CHARACTER*64 INFILE,CASE
C##################################################################===##
C
C   DATA STATEMENTS
C
C##################################################################===##
C   16 CONTAMINANTS SIMULATED:
C           6 METALS
C          10 ORGANICS
C-----------------------------
      DATA CHMNAM
     # /'ARSE','NIC ','    ','    ','    ',
     #          'CADM','IUM ','    ','    ','    ',
     #          'COPP','ER  ','    ','    ','    ',
     #          'LEAD','    ','    ','    ','    ',
     #          'MERC','URY ','    ','    ','    ',
     #          'NICK','EL  ','    ','    ','    ',
     #          'BENZ','ENE ','    ','    ','    ',
     #          'BENZ','O(A)','PYRE','NE  ','    ',
     #          'BIS(','2ETH','EX)P','THAL','ATE ',
     #          'CHLO','RDAN','E   ','    ','    ',
     #          'DDT/','DDE/','DDD ','    ','    ',
     #          'DIME','THYL','NITR','OSAM','INE ',
     #          'LIND','ANE ','    ','    ','    ',
     #          'PCBS','    ','    ','    ','    ',
     #          'TRIC','HLOR','OETH','YLEN','E   ',
     #          'TOXA','PHEN','E   ','    ','    '/
C-----------------------------------------------
C   FLAG IDENTIFYING METALS (0) OR ORGANICS (1).
C-----------------------------------------------
      DATA IORGNC /0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1/
C-------------------------------------------
C   EFFECTS THRESHOLD VALUES (1.E-04 LEVELS)
```

```
C-------------------------------------------
      DATA HEL /0.05,0.01,1.3,0.05,0.002,1.75,0.005,
     # 3.0E-05,0.0245,2.1E-04,0.00102,1.E-05,0.004,4.54E-05,
     # 0.005,0.005/
C------------------------------
C    12 MATERIAL TYPES SIMULATED.
C------------------------------
      DATA SOILID
     # /'CLAY','    ','    ','    ','SILT','Y CL','AY  ','    ',
     #          'SILT','Y CL','AY L','OAM ','CLAY',' LOA','M   ','    ',
     #          'SAND','Y CL','AY L','OAM ','SAND','Y SI','LT L','OAM ',
     #          'SILT','Y LO','AM  ','    ','SAND','Y LO','AM  ','    ',
     #          'LOAM','Y SA','ND  ','    ','SAND','    ','    ','    ',
     #          'FRAC','. SA','NDST','ONE ','LIME','STON','E   ','    '/
C-------------------------------------------------------------
C   HYDRAULIC CONDUCTIVITIES (M/DAY) FOR THE 12 MATERIAL TYPES.
C-------------------------------------------------------------
      DATA HC /0.032,0.32,3.2,1.0,3.2,32.0,32.0,100,320.0,3200.0,
     #          1.0,10./
C-------------------------------------------------------------------
C   'B' VALUE FOR UNSATURATED ZONE TRAVEL TIME CALCULATION FOR THE 12
C      MATERIAL TYPES.
C   'B' VALUE IS NEGATIVE THE SLOPE OF THE LOG-LOG PLOT OF HEAD VS
C      THETA.
C-------------------------------------------------------------------
           DATA B /11.7,9.9,7.5,8.5,7.5,5.4,4.8,6.3,5.6,4.0,4.0,4.0/
C----------------------------------------------
C   EFFECTIVE POROSITY FOR THE 12 MATERIAL TYPES.
C----------------------------------------------
      DATA THTA/0.46,0.44,0.42,0.4,0.39,0.38,0.37,0.36,0.35,0.34,0.01,
     #          0.10/
C-------------------------------------------------------------
C   EFFECTIVE BULK DENSITY FOR THE 12 MATERIAL TYPES (KG/CU M).
C-------------------------------------------------------------
      DATA EFBD /1400.,1500.,1500.,1600.,1600.,1600.,1700.,1700.,
     #          1700.,1750.,2620.,2390./
C--------------------------------------------------------------
C   ORGANIC CARBON CONTENT FOR THE 10 ORGANICS (KD - KOC * FOC).
C--------------------------------------------------------------
      DATA KOC /0.,0.,0.,0.,0.,0.,74.,5.5E+06,2.E+09,1.7E+05,
     #          5.0E+06,0.04,1080.,3.2E+05,198.,960./
C---------------------------------------------------
C   SATURATED DISTRIBUTION COEFFICIENT FOR THE 7 METALS.
C---------------------------------------------------
      DATA SAKD /5.86,14.9,41.9,234.0,322.0,12.2,
     #          0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
C--------------------------------------------------------------------
C   FRACTION OF ORGANIC CARBON FOR THE 12 SOIL TYPES (KD - KOC * FOC).
```

```
C-----------------------------------------------------------------------
      DATA FOC /0.01,0.01,0.013,0.01,0.005,0.005,0.001,0.005,0.001,
     #           0.0001,0.0001,0.0001/
C--------------------------------------------------------------------
C   UNSATURATED LAYER DISTRIBUTION COEFFICIENT FOR THE 8 METALS AND
C      THE 12 MATERIAL TYPES (L/KG).
C--------------------------------------------------------------------
      DATA UNKD /19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           19.4,423.,92.2,597.0,580.0,58.6,
     #           5.86,14.9,41.9,234.0,322.0,12.2,
     #           5.86,14.9,41.9,234.0,322.0,12.2,
     #           5.86,14.9,41.9,234.0,322.0,12.2,
     #           5.86,14.9,41.9,234.0,322.0,12.2/
C------------------------------------
C ANAEROBIC UNSATURATED DECAY CONSTANTS
C------------------------------------
           DATA ULAMBD /0.,0.,0.,0.,0.,0.,
     #          0.,0.,0.,0.,0.,0.,1.0,0.,0.,0./
C--------------------------------------------------------------------
C   AEROBIC UNSATURATED DECAY CONSTANTS FOR THE 16 CONTAMINANTS (1/T).
C--------------------------------------------------------------------
C     DATA AULAMB /0.,0.,0.,0.,0.,0.,3.90,3.65,0.,0.584,
C    #           0.0198,5.11,0.657,0.1153,0.,0.063/
C-----------------------------------------
C ANAEROBIC SATURATED DECAY CONSTANTS (1/YR)
C-----------------------------------------
      DATA SLAMBD /0.,0.,0.,0.,0.,0.,
     #          0.,0.,0.,8.43,.904,607.1,1.0,0.,0.904,0./
C------------------------------------------------------------------
C AEROBIC SATURATED DECAY CONSTANT FOR THE 16 CONTAMINANTS (1/T).
C------------------------------------------------------------------
C     DATA ASLAMB /0.,0.,0.,0.,0.,0.,
C    #           0.,0.,0.00035,0.,0.0584,0.,0.,0.,0.,0.063/
C--------------------
C HENRY'S LAW CONSTANTS
C--------------------
      DATA H/0.,0.,0.,0.,0.,0.,
     # 0.,1.7E-08,.004625,0.002,0.0017,0.02,0.,0.16,0.,0./
C-----------------
C MOLECULAR WEIGHTS
C-----------------
      DATA RMW/74.92,51.996,63.54,207.2,200.59,58.70,
     # 78.12,252.32,391.,410.,354.5,74.08,290.83,300.,132.,44./
C#########=================================================================
C
C   BEGIN MAIN PROGRAM
C
C#########=================================================================
      WRITE (*,1)
1     FORMAT ('      ****************************************'/
     &        '        *           PROGRAM SLUDGIN            *'/
     &        '        *                                      *'/
     &        '        *   WELCOME TO THE SLUDGEMAN COMPUTER  *'/
     &        '        *    PROGRAM FOR EVALUATING LANDFILL   *'/
     &        '        * DISPOSAL OF MUNICIPAL SEWAGE SLUDGE  *'/
     &        '        *                                      *'/
     &        '        ****************************************'///
     &        '        SLUDGEMAN WILL NOW CREATE AN INPUT DATA'/
     &        '        FILE USING THE DATA FOR YOUR SITE.'/
     &        '        IF YOU HAVE NOT ENTERED DATA FOR THIS'/
     &        '        SITE OR APPLICATION BEFORE, ENTER 1,'/
     &        '        OTHERWISE ENTER 0'/)
2     WRITE (*,3)
3     FORMAT ('      ENTER 1 TO CREATE NEW DATA FILE'/
     &        '        ENTER 0 IF DATA FILE ALREADY EXISTS'//)
      READ (*,4,ERR=2) ANS
4     FORMAT (A)
      IF (ANS .EQ.'0') GOTO 9999
      IF(.NOT.((ANS .NE.'0') .AND. (ANS .NE. '1'))) GO TO 32758
      WRITE (*,5)
5     FORMAT (//'       INVALID SELECTION ')
      GOTO 2
C-----------------------------------------------------------------------
C OPEN 7: "SLUDGE.OUT" -- PRIMARY OUTPUT FILE
C      8: "SLUDGE.TMP" -- SECONDARY OUTPUT FILE FOR MAKING CORRECTIONS
C-----------------------------------------------------------------------
32758 OPEN (7,FILE='SLUDGIN.DES',STATUS='NEW')
      OPEN (8,FILE='SLUDGIN.OUT',STATUS='NEW')
C-----------------
C READ IN CASE NAME
C-----------------
      WRITE (*,100)
100   FORMAT (/' ENTER THE CASE NAME')
      READ (*,'(A)') CASE
C---------------------------------
C READ IN CONTAMINANT CONCENTRATIONS
C---------------------------------
      DO 32757 I=1,16
110   WRITE (*,120) (CHMNAM(J,I),J=1,5)
120   FORMAT (/' ENTER LEACHATE CONCENTRATION (MG/L) FOR ',5A4)
```

```
      READ (*,130,ERR=110) CL(I)
130   FORMAT (F15.0)
140   WRITE (*,150) (CHMNAM(J,I),J=1,5)
150   FORMAT (' ENTER DRY SLUDGE CONCENTRATION (MG/KG) FOR ',5A4)
      READ (*,130,ERR=140) CS(I)
32757 CONTINUE
C-------------------
C READ IN SLUDGE DATA
C-------------------
160   WRITE (*,170)
170   FORMAT (/' ENTER SLUDGE MOISTURE CONTENT (KG/KG)')
      READ (*,130,ERR=160) SLMC
180   WRITE (*,190)
190   FORMAT (/' ENTER SLUDGE STORAGE CAPACITY (KG/KG)')
      READ (*,130,ERR=180) SLSC
200   WRITE (*,210)
210   FORMAT (/' ENTER SLUDGE DENSITY (KG/CU M)')
      READ (*,130,ERR=200) SLDN
C-----------------
C READ IN SITE DATA
C-----------------
220   WRITE (*,230)
230   FORMAT (/' ENTER NET RECHARGE (M/YR)')
      READ (*,130,ERR=220) STRC
C-----------------------------------------------
C DONT'T READ DEPTH TO GROUNDWATER, CALCULATE AS SUM
C OF INDIVIDUAL UNSATURATED LAYERS, TTHIK
C-----------------------------------------------
240   WRITE (*,250)
250   FORMAT(/' ENTER DISTANCE FROM LANDFILL BOUNDARY TO MONITORING'
     #          ' LOCATION (M)')
      READ (*,130,ERR=240) STDB
320   WRITE (*,330)
330   FORMAT (/' ENTER LANDFILL WIDTH (M) (PERPENDICULAR TO THE',
     #          ' FLOW PATH)')
      READ (*,130,ERR=320) STWID
340   WRITE (*,350)
350   FORMAT (/' ENTER LANDFILL LENGTH (M)')
      READ (*,130,ERR=340) STLEN
360   WRITE (*,370)
370   FORMAT (/' ENTER FILL HEIGHT (M)')
      READ (*,130,ERR=360) FLHT
C----------------------------
C READ IN UNSATURATED ZONE DATA
C----------------------------
      TTHIK = 0.
      SUMTHT = 0.
      SUMEBD = 0.
      DO 32756 K-1,16
      SUMUKD(K) - 0.
32756 CONTINUE
500   WRITE (*,510)
510   FORMAT (/' ENTER NUMBER OF LAYERS IN UNSATURATED ZONE',
     #          ' (1 TO 5 ALLOWED)')
      READ (*,520,ERR-500) NLAYS
520   FORMAT (I5)
      IF(.NOT.((NLAYS .LT. 1) .OR. (NLAYS .GT. 5))) GO TO 32755
      WRITE (*,530)
530   FORMAT (/' ERROR -- UNALLOWABLE VALUE')
      GOTO 500
C
32755 DO 32754 I-1,NLAYS
540   WRITE (*,550) I
550        FORMAT (/' ENTER MATERIAL TYPE FOR LAYER ',I2,
     #          /'  1 - CLAY'
     #          /'  2 - SILTY CLAY'
     #          /'  3 - SILTY CLAY LOAM'
     #          /'  4 - CLAY LOAM'
     #          /'  5 - SANDY CLAY LOAM'
     #          /'  6 - SANDY SILT LOAM'
     #          /'  7 - SILTY LOAM'
     #          /'  8 - SANDY LOAM'
     #          /'  9 - LOAMY SAND'
     #          /' 10 - SAND'
     #          /' 11 - FRACTURED SANDSTONE'
     #          /' 12 - FRACTURED LIMESTONE')
      READ (*,520,ERR-540) ITYPE(I)
      IF(.NOT.((ITYPE(I) .LT. 1) .OR. (ITYPE(I) .GT. 12))) GO TO 32753
      WRITE (*,510)
      GOTO 540
C
32753 CONTINUE
555   WRITE (*,560) I
560   FORMAT (/' ENTER THICKNESS OF LAYER ',I2,' (M)')
      READ (*,130,ERR-555) THIK(I)
C
      UNHC(I) - HC(ITYPE(I))
      WRITE (*,570) UNHC(I)
570   FORMAT(/' A REASONABLE VALUE OF SATURATED HYDRAULIC CONDUCTIVTY'
     #          /' FOR THIS MATERIAL WOULD BE ',1PE10.3,' M/YR')
580   WRITE (*,890)
      READ (*,520,ERR-580) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32752
590   WRITE (*,600) I
600   FORMAT (/' ENTER A NEW HYDRAULIC CONDUCTIVITY FOR LAYER'I3,
     #          ' (M/YR)')
```

```
      READ (*,130,ERR-590) UNHC(I)
C
32752 UB(I) - B(ITYPE(I))
      WRITE (*,610) UB(I)
610   FORMAT(/' A REASONABLE VALUE OF SLOPE OF SOIL CURVE'
     #          /' ("B VALUE") FOR THIS MATERIAL WOULD BE ',F10.4)
620   WRITE (*,890)
      READ (*,520,ERR-620) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32751
630   WRITE (*,640) I
640   FORMAT (/' ENTER A NEW "B VALUE" FOR LAYER ',I3)
      READ (*,130,ERR-630) UB(I)
C
32751 UTHTA(I) - THTA(ITYPE(I))
      WRITE (*,650) UTHTA(I)
650   FORMAT(/' A REASONABLE VALUE OF EFFECTIVE POROSITY'
     #          /' FOR THIS MATERIAL WOULD BE ',F10.4,' CU M/CU M')
660   WRITE (*,890)
      READ (*,520,ERR-660) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32750
670   WRITE (*,680) I
680   FORMAT (/' ENTER A NEW EFFECTIVE POROSITY FOR LAYER'I3,
     #          ' (CU M/CU M)')
      READ (*,130,ERR-670) UTHTA(I)
C
32750 UEFBD(I) - EFBD(ITYPE(I))
      WRITE (*,690) UEFBD(I)
690   FORMAT(/' A REASONABLE VALUE OF EFFECTIVE BULK DENSITY'
     #          /' FOR THIS MATERIAL WOULD BE ',F10.4,' KG/CU M')
700   WRITE (*,890)
      READ (*,520,ERR-700) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32749
710   WRITE (*,720) I
720   FORMAT (/' ENTER A NEW EFFECTIVE BULK DENSITY FOR LAYER'I3,
     #          ' (KG/CU M)')
      READ (*,130,ERR-710) UEFBD(I)
C---------------------------------------------------
C   CALCULATE TOTAL THICKNESS,
C      WEIGHTED AVERAGE POROSITY OF ALL LAYERS, AND
C      WEIGHTED AVERAGE BULK DENSITY OF ALL LAYERS.
C---------------------------------------------------
32749 TTHIK - TTHIK + THIK(I)
      SUMTHT - SUMTHT + THIK(I) * UTHTA(I)
      SMEFBD - SMEFBD + THIK(I) * UEFBD(I)
C-----------------------------------------------------
C   CALCULATE KD'S FOR THE ORGANICS AS KOC TIMES FOC.
C-----------------------------------------------------
      DO 32748 L-1,16
      IF(.NOT.(IORGNC(L) .EQ. 1)) GO TO 32747
      SUMUKD(L) - SUMUKD(L) + (KOC(L) * FOC(ITYPE(I)) * THIK(I))
C-----------------------------
C   SET THE KD'S FOR THE METALS.
C-----------------------------
32747 IF(.NOT.(IORGNC(L) .EQ. 0)) GO TO 32746
      SUMUKD(L) - SUMUKD(L) + (UNKD(L,ITYPE(I)) * THIK(I))
32746 CONTINUE
32748 CONTINUE
32754 CONTINUE
C---------------------------------------------------------------------
C   CALCULATE THE WEIGHTED AVERAGE POROSITY, BULK DENSITY, AND
C      DISTRIBUTION COEFFICIENT OF ALL UNSATURATED LAYERS BY DIVIDING
C      BY TOTAL THICKNESS.
C---------------------------------------------------------------------
      IF (TTHIK .LE. 0.) GO TO 830
      AVTHTA - SUMTHT / TTHIK
      AVEFBD - SMEFBD / TTHIK
      DO 32744 I-1,16
      UKD(I) - SUMUKD(I) / TTHIK
32744 CONTINUE
C------------------------------------------------------------
C ENTER LONGITUDINAL DISPERSIVITY VALUE FOR UNSATURATED ZONE
C------------------------------------------------------------
730   WRITE (*,740)
740   FORMAT(/' ENTER AN AVERAGE LONGITUDINAL DISPERSIVITY VALUE'/
     # ' FOR THE ENTIRE UNSATURATED ZONE.  <CR> DEFAULTS TO 1/10'/
     # ' THE DEPTH TO GROUNDWATER FROM THE BOTTOM OF THE LANDFILL'/)
      READ (*,130,ERR-730) UDX
      IF (UDX.EQ.0.) UDX - 0.1 * TTHIK
C------------------------------------------------------
C ENTER UNSATURATED ZONE KD VALUES OR USE DEFAULT VALUES
C------------------------------------------------------
750   WRITE (*,760)
760   FORMAT (/' DO YOU WISH TO ENTER KD VALUES FOR THE'/
     #          ' UNSATURATED ZONE OR USE DEFAULT VALUES?'/
     #          '   ENTER 0 TO USE DEFAULT VALUES OR'/
     #          '   ENTER 1 TO ENTER VALUES')
      READ (*,520,ERR-750) IKD
      IF(.NOT.(IKD .EQ. 1)) GO TO 32743
      DO 32742 II - 1,16
770   WRITE (*,780) (CHMNAM(J,II),J-1,5)
780   FORMAT (/' ENTER UNSATURATED ZONE KD (L/KG) FOR ',5A4)
      READ (*,130,ERR-770) UKD(II)
32742 CONTINUE
32743 IF(.NOT.((IKD .NE. 0) .AND. (IKD .NE. 1))) GO TO 32741
      WRITE (*,530)
      GOTO 750
```

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C--------------------------------------------------------------
C ENTER UNSATURATED ZONE DEGRADATION RATES OR USE DEFAULT VALUES
C--------------------------------------------------------------
32741 CONTINUE
790   WRITE (*,800)
800   FORMAT (/' SELECT DESIRED OPTION FOR UNSATURATED ZONE'/
     #          ' DEGRADATION RATE CONSTANTS:'/
     #          ' (0) USE ANAEROBIC DECAY RATES'/
     #          ' (1) SPECIFY USER DEFINED DECAY RATES'/)
      READ (*,520,ERR-790) IULAM
      IF (IULAM .NE. 1) GO TO 32740
      DO 32739 II - 1,16
810   WRITE (*,820) (CHMNAM(J,II),J-1,5)
820   FORMAT (/' ENTER UNSATURATED DEGRADATION RATE CONSTANT'/
     #          ' (1/YR) FOR ',5A4)
      READ (*,130,ERR-810) ULAMBD(II)
32739 CONTINUE
32740 IF (IULAM.EQ.0 .OR. IULAM.EQ.1) GO TO 32738
      WRITE (*,530)
      GOTO 790
C---------------------------
C READ IN SATURATED ZONE DATA
C---------------------------
32738 CONTINUE
830   WRITE (*,840)
840   FORMAT (/' SELECT THE APPROPRIATE GROUNDWATER PH (SU)'
     #          /' AND EH (MV) CATEGORY.  IF THE ACTUAL PH AND EH VALUES'
     #          /' ARE NOT LISTED, TO BE CONSERVATIVE, SELECT THE LOWER'
     #          /' PH VALUE AND THE HIGHER EH VALUE'
     #          /'          1 - PH 6.0, EH -200',
     #          /'          2 - PH 6.0, EH +150',
     #          /'          3 - PH 6.0, EH +500',
     #          /'          4 - PH 7.0, EH -200',
     #          /'          5 - PH 7.0, EH +150',
     #          /'          6 - PH 7.0, EH +500',
     #          /'          7 - PH 8.1, EH -206',
     #          /'          8 - PH 8.1, EH +106')
      READ (*,520,ERR-830) IPHEH
      IF((1).NE.(IPHEH)) GO TO 32736
      GWPH - 6.0
      GWEH - -200.
      GO TO 32737
32736 IF((2).NE.(IPHEH)) GO TO 32735
      GWPH - 6.0
      GWEH - 150.
      GO TO 32737
32735 IF((3).NE.(IPHEH)) GO TO 32734
      GWPH - 6.0
      GWEH = 500.
      GO TO 32737
32734 IF((4).NE.(IPHEH)) GO TO 32733
      GWPH = 7.0
      GWEH = -200.
      GO TO 32737
32733 IF((5).NE.(IPHEH)) GO TO 32732
      GWPH = 7.0
      GWEH = 150.
      GO TO 32737
32732 IF((6).NE.(IPHEH)) GO TO 841
      GWPH = 7.0
      GWEH = 500.
      GO TO 32737
841   IF (7.NE.IPHEH) GO TO 842
      GWPH = 8.1
      GWEH = -206.
      GO TO 32737
842   IF (8.NE.IPHEH) GO TO 32731
      GWPH = 8.1
      GWEH = 106.
      GO TO 32737
32731 WRITE (*,530)
      GOTO 830
32737 CONTINUE
850   WRITE (*,860)
860    FORMAT (/' ENTER MATERIAL TYPE FOR SATURATED ZONE',
     #          /'  1 = CLAY'
     #          /'  2 = SILTY CLAY'
     #          /'  3 = SILTY CLAY LOAM'
     #          /'  4 = CLAY LOAM'
     #          /'  5 = SANDY CLAY LOAM'
     #          /'  6 = SANDY SILT LOAM'
     #          /'  7 = SILTY LOAM'
     #          /'  8 = SANDY LOAM'
     #          /'  9 = LOAMY SAND'
     #          /' 10 = SAND'
     #          /' 11 = FRACTURED SANDSTONE'
     #          /' 12 = FRACTURED LIMESTONE')
      READ (*,520,ERR=850) ISATYP
      IF(.NOT.((ISATYP .LT. 1) .OR. (ISATYP .GT. 12))) GO TO 32730
      WRITE (*,530)
      GOTO 850
32730 GWHC = HC(ISATYP)
      WRITE (*,870) GWHC
870   FORMAT (/' A REASONABLE VALUE OF SATURATED HYDRAULIC CONDUCTIVTY'
     #          /' FOR THIS MATERIAL WOULD BE ',F10.3,' M/YR')
880   WRITE (*,890)
```

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890   FORMAT (/' DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y=1, N=0)')
      READ (*,520,ERR=880) IFLG
      IF(.NOT.(IFLG.EQ.1)) GO TO 32729
1231  WRITE (*,123)
123   FORMAT (/' ENTER A NEW AQUIFER HYDRAULIC CONDUCTIVITY (M/YR)')
      READ (*,130,ERR=1231) GWHC
32729 CONTINUE
1241  WRITE (*,124)
124   FORMAT (/' ENTER AQUIFER EFFECTIVE POROSITY (CU M/CU M)')
      READ (*,130,ERR=1241) GWEP
1251  WRITE (*,125)
125   FORMAT (/' ENTER AQUIFER HYDRAULIC GRADIENT (M/M)')
      READ (*,130,ERR=1251) GWGR
1261  WRITE (*,126)
126   FORMAT (/' ENTER AQUIFER EFFECTIVE BULK DENSITY (KG/CU M)')
      READ (*,130,ERR=1261) GWEBD
1271  WRITE (*,127)
127   FORMAT(/' ENTER AQUIFER THICKNESS (M)')
      READ (*,130,ERR=1271) AQDEP
1281  WRITE (*,128)
128   FORMAT(/' ENTER AQUIFER WIDTH (M) (PERPENDICULAR TO THE FLOW',
     #          ' PATH)')
      READ (*,130,ERR=1281) AQWID
260   WRITE (*,270)
270   FORMAT(/' ENTER SATURATED ZONE DISPERSIVITY IN X-DIRECTION'/
     # ' <CR> = 1/10 THE DISTANCE TO THE MONITORING LOCATION')
      READ (*,130,ERR=260) DX
      IF (DX.EQ.0.) DX = 0.1 * STDB
280   WRITE (*,290)
290   FORMAT(/' ENTER SATURATED ZONE DISPERSIVITY IN Y-DIRECTION'/
     # ' <CR> = 1/100 THE DISTANCE TO THE MONITORING LOCATION')
      READ (*,130,ERR=280) DY
      IF (DY.EQ.0.) DY = 0.01 * STDB
300   WRITE (*,310)
310   FORMAT(/' ENTER SATURATED ZONE DISPERSIVITY IN Z-DIRECTION'/
     # ' <CR> = 1/100 THE DISTANCE TO THE MONITORING LOCATION')
      READ (*,130,ERR=300) DZ
      IF (DZ.EQ.0.) DZ = 0.01 * STDB
C-----------------------------------------------------
C ENTER SATURATED ZONE KD VALUES OR USE DEFAULT VALUES
C-----------------------------------------------------
1290  WRITE (*,1300)
1300  FORMAT (/' DO YOU WISH TO ENTER KD VALUES FOR THE'/
     #         '   SATURATED ZONE OR USE DEFAULT VALUES?'/
     #         '   ENTER 0 TO USE DEFAULT VALUES OR'/
     #         '   ENTER 1 TO ENTER VALUES')
      READ (*,520,ERR=1290) IKD
      IF(.NOT.(IKD .EQ. 1)) GO TO 32728
      DO 32727 II - 1,16
1311  WRITE (*,131) (CHMNAM(J,II),J-1,5)

131   FORMAT (/' ENTER SATURATED ZONE KD (L/KG) FOR ',5A4)
      READ (*,130,ERR-1311) SAKD(II)
32727 CONTINUE
32728 IF(.NOT.((IKD .NE. 0) .AND. (IKD .NE. 1))) GO TO 32726
      WRITE (*,530)
      GOTO 1290
C-----------------------------------------------------------
C ENTER SATURATED ZONE DEGRADATION RATES OR USE DEFAULT VALUES
C-----------------------------------------------------------
32726 CONTINUE
132   WRITE (*,133)
133   FORMAT (/' SELECT DESIRED OPTION FOR DEGRADATION RATES'/
     #          ' FOR THE SATURATED ZONE:'/
     #          ' (0) USE ANAEROBIC DECAY RATES'/
     #          ' (1) SPECIFY USER DEFINED DECAY RATES'/)
      READ (*,520,ERR-132) ISLAM
      IF (ISLAM .NE. 1) GO TO 32725
      DO 32724 II - 1,16
1341  WRITE (*,134) (CHMNAM(J,II),J-1,5)
134   FORMAT (/' ENTER SATURATED DEGRADATION RATE CONSTANT'/
     #          ' (1/YR) FOR ',5A4)
      READ (*,130,ERR-1341) SLAMBD(II)
32724 CONTINUE
32725 IF (ISLAM.EQ.0 .OR. ISLAM.EQ.1) GO TO 32723
      WRITE (*,530)
      GOTO 132
32723 DO 32722 I-1,16
1351  WRITE (*,135) (CHMNAM(J,I),J-1,5)
135   FORMAT(/' ENTER BACKGROUND GROUNDWATER CONCENTRATION (MG/L) OF ',
     # 5A4)
      READ (*,130,ERR-1351) CBACK(I)
32722 CONTINUE
C-----------------------
C ENTER VAPOR PATHWAY DATA
C-----------------------
      WRITE (*,*)'ENTER AVERAGE SURFACE WIND VELOCITY (M/SEC)'
      READ (*,130) VEL
      IF (VEL.EQ.0.) VEL - 1.
      WRITE (*,*)'ENTER AVERAGE AIR TEMPERATURE (DEGREES CENTIGRADE)'
      READ (*,130) TEMP
      IF (TEMP.EQ.0.) TEMP - 15.
      WRITE (*,*)'ENTER AIR-FILLED POROSITY OF THE COVER SOIL'
      READ (*,130) PA
      IF (PA.EQ.0.) PA - .1
      WRITE (*,*)'ENTER TOTAL POROSITY OF THE COVER SOIL'
      READ (*,130) PT
      IF (PT.EQ.0.) PT - .4
      WRITE (*,*)'ENTER COVER THICKNESS DURING ACTIVE PERIOD (M)'
      READ (*,130) TCA
      IF (TCA.EQ.0.) TCA - .3
      WRITE (*,*)'ENTER COVER THICKNESS DURING POST-CLOSURE PERIOD (M)'
      READ (*,130) TCP
      IF (TCP.EQ.0.) TCP - 1.
      WRITE (*,*)'ENTER ACTIVE CELL LENGTH (M)'
      READ (*,130) XA
      IF (XA.EQ.0.) XA - 8.
      WRITE (*,900)
900   FORMAT(' DO U WISH TO USE DEFAULT VALUES'/
     + ' FOR HENRY''S LAW CONSTANTS AND MOLECULAR WEIGHTS (0)'/
     + ' OR ENTER YOUR OWN (1)?')
      READ (*,520) IH
      IF (IH.EQ.1) THEN
        WRITE (*,910)
910   FORMAT(/' SELECT FOR INPUT:'/
     + '(0) MODIFIED HENRY''S LAW CONSTANTS'/
     + '(1) HENRY''S LAW CONSTANTS')
        READ (*,520) IH
        DO 950 I-1,16
          IF (IH.EQ.0) THEN
            WRITE (*,920) (CHMNAM(J,I),J-1,5)
920         FORMAT(/' ENTER MODIFIED HENRY''S LAW CONSTANT FOR ',5A4)
          ELSE
            WRITE (*,930) (CHMNAM(J,I),J-1,5)
930         FORMAT(/' ENTER HENRY''S LAW CONSTANT FOR ',5A4)
            READ (*,*) H(I)
            H(I) - H(I)*12188.8/TEMP
          END IF
          WRITE (*,940) (CHMNAM(J,I),J-1,5)
940       FORMAT(' ENTER MOLECULAR WEIGHT FOR '5A4)
          READ (*,*) RMW(I)
950     CONTINUE
      END IF

C960      WRITE (*,965)
C965   FORMAT(/' DO YOU WISH TO BACK-CALCULATE ALLOWABLE INPUT',/
C     + ' (DRY WGHT) CONCENTRATIONS?  1-YES')
C      READ (*,*,ERR-960) ITER
C#######################################################################
C
C ECHO INPUT DATA TO OUTPUT FILE
C
C#######################################################################
      CALL DATE(10,CHDATE)
      CALL TIME(10,CHTIME)
      WRITE (7,7001)CHDATE,CHTIME
7001  FORMAT (17X,'****************** SLUDGEMAN ******************'/
     #          17X,'*    DRAFT COMMENT VERSION 0.00, DEC., 1987   *'/
     #          17X,'*                                             *'/
     #          17X,'*           OUTPUT FILE SLUDGIN.OUT           *'/
     #          17X,'*       CREATED BY PROGRAM SLUDGIN.EXE        *'/
     #          17X,'*           ON ',A10,' AT ',A10,'       *'/
     #          17X,'*                                             *'/
     #          17X,'*    FILE CONTAINS HARD COPY OF ALL INPUT     *'/
     #          17X,'*    DATA SUPPLIED TO PROGRAM SLUDGIN.EXE     *'/
     #          17X,'*                                             *'/
     #          17X,'***********************************************')
      WRITE (7,7010) CASE
      WRITE (8,8010) CASE
7010  FORMAT (//,1X,'CASE NAME: 'A64,//)
8010  FORMAT (1X,A64)
      WRITE (7,701)
701   FORMAT (1X,79('-'),/,25X,'CONTAMINANT CONCENTRATION DATA',
     #          /,1X,79('-'),//
     # 1X,'CONTAMINANT',11X,'CL, MG/L',4X,'CS, MG/KG',3X'HEL, MG/KG'/)
      DO 32721 I=1,16
      WRITE (7,702) (CHMNAM(J,I),J=1,5),CL(I),CS(I),HEL(I)
      WRITE (8,802) CL(I),CS(I),HEL(I)
702   FORMAT (1X,5A4,1P3E12.4)
802   FORMAT (1X,1P3E12.4)
32721 CONTINUE
C---------------------
C WRITE OUT SLUDGE DATA
C---------------------
      WRITE (7,703)
703   FORMAT (/1X,79('-'),/,34X,'SLUDGE DATA'/,1X,79('-'),/)
      WRITE (7,704) SLMC
      WRITE (8,804) SLMC
704   FORMAT (' SLUDGE MOISTURE CONTENT = ',F8.4,' KG/KG')
804   FORMAT (1X,F8.4)
      WRITE (7,705) SLSC
      WRITE (8,804) SLSC
705   FORMAT (' SLUDGE STORAGE CAPACITY = ',F8.4,' KG/KG')
      WRITE (7,706) SLDN
      WRITE (8,806) SLDN
706   FORMAT (' SLUDGE DENSITY = ',F8.2,' KG/CU M')
806   FORMAT (1X,F8.2)
      WRITE (7,707)
C-------------------
C WRITE OUT SITE DATA
C-------------------
707   FORMAT (/,1X,79('-'),/,35X,'SITE DATA',/,1X,79('-'),/)
```

```
      WRITE (7,708) STRC
      WRITE (8,804) STRC
708   FORMAT (' NET RECHARGE = ',F8.4,' M/YR')
      WRITE (7,709) TTHIK
C     WRITE (8,804) TTHIK
709   FORMAT (' DEPTH TO GROUNDWATER = ',F8.4,' M')
      WRITE (7,7100) STDB
      WRITE (8,812) STDB
7100  FORMAT (' DISTANCE TO LANDFILL BOUNDARY = ',F10.2,' M')
      WRITE (7,724) STWID
      WRITE (8,812) STWID
724   FORMAT (' SITE WIDTH = ',F8.2,' M')
      WRITE (7,725) STLEN
      WRITE (8,812) STLEN
725   FORMAT (' SITE LENGTH = ',F8.2,' M')
      WRITE (7,726) FLHT
      WRITE (8,812) FLHT
726   FORMAT (' FILL HEIGHT = ',F8.2,' M')
      WRITE (8,812) UDX
C-------------------------------
C WRITE OUT UNSATURATED ZONE DATA
C-------------------------------
      WRITE (7,711) UDX
711   FORMAT (/,1X,79('='),/,29X,'UNSATURATED ZONE DATA',/,1X,79('='),
     #          //' AVERAGE LONGITUDINAL DISPERSIVITY = ',1PE10.2//
     #          66X,'EFF BULK'/54X,'THETA SAT',3X,'DENSITY'
     #          /1X,'MATRIX',8X,'THICKNESS, M',4X,'K, M/YR',9X,'B',6X,
     #          'CU M/CU M',3X,'KG/CU M'/)
      WRITE (8,8100) NLAYS
8100  FORMAT(1X,I5)
      DO 32720 I=1,NLAYS
      WRITE (7,712) (SOILID(J,ITYPE(I)),J=1,4),THIK(I),
     #          UNHC(I),UB(I),UTHTA(I),UEFBD(I)
      WRITE (8,8100) ITYPE(I)
      WRITE (8,811) THIK(I)
      WRITE (8,811) UNHC(I)
      WRITE (8,811) UB(I)
      WRITE (8,811) UTHTA(I)
      WRITE (8,811) UEFBD(I)
811   FORMAT (1X,F10.2)
812   FORMAT (1X,1P3E10.3)
712   FORMAT (1X,4A4,2X,F8.2,2X,1PE10.3,2X,0PF8.2,2(2X,F10.2))
32720 CONTINUE
C     IF (TTHIK .GT. 0.)
      WRITE (7,713) AVTHTA,AVEFBD
713   FORMAT (' WEIGHTED AVE',38X,F10.2,2X,F10.2)
      WRITE (7,7131)
7131  FORMAT (//42X,'UNSATURATED'/,26X,'UNSATURATED',5X,
     #          'DEGRADATION RATE',/,1X,'CONTAMINANT',14X,'KD, L/KG',8X,
     #          'CONSTANT, 1/YR',/)
      DO 32717 I=1,16
      WRITE (7,7132) (CHMNAM(J,I),J=1,5),UKD(I),ULAMBD(I)
7132  FORMAT (1X,5A4,2(5X,1PE10.3))
          WRITE (8,813) UKD(I),ULAMBD(I)
813       FORMAT (2(1X,1PE10.3))
32717 CONTINUE
      GO TO 32719
C-----------------------------
C WRITE OUT SATURATED ZONE DATA
C-----------------------------
32719 WRITE (7,714)
      WRITE (8,1816) IPHEH
714   FORMAT (/1X,79('='),/,30X,'SATURATED ZONE DATA',/,1X,79('='),/)
      WRITE (7,1714) IPHEH
1714  FORMAT (' THE PH / EH CATEGORY IS =',I2)
      WRITE (7,715) GWPH
715   FORMAT (' GROUNDWATER PH = ',F8.4,' SU')
      WRITE (7,716) GWEH
716   FORMAT (' GROUNDWATER EH = ',F8.2,' MV')
          WRITE (7,1716) ISATYP
1716      FORMAT (' AQUIFER MATERIAL TYPE =  ',I2)
          WRITE (8,1816) ISATYP
1816      FORMAT (I5)
      WRITE (7,717) GWHC
      WRITE (8,812) GWHC
717   FORMAT (' AQUIFER HYDRAULIC CONDUCTIVITY = ',E10.4,' M/YR')
      WRITE (7,718) GWEP
      WRITE (8,812) GWEP
718   FORMAT (' AQUIFER EFFECTIVE POROSITY = ',F8.2,' CU M/CU M')
      WRITE (7,719) GWGR
      WRITE (8,812) GWGR
719   FORMAT (' GROUNDWATER GRADIENT = ',E10.4,' M/M')
      WRITE (7,7200) GWEBD
      WRITE (8,812) GWEBD
7200  FORMAT (' AQUIFER EFFECTIVE BULK DENSITY = ',F8.2,' KG/CU M')
      WRITE (7,1724) AQDEP
      WRITE (8,812) AQDEP
1724  FORMAT (' AQUIFER THICKNESS = ',F8.2,' M')
      WRITE (7,1725) AQWID
      WRITE (8,812) AQWID
1725  FORMAT (' AQUIFER WIDTH = ',1PE12.2,' M')
      WRITE (7,721) DX,DY,DZ
      WRITE (8,812) DX,DY,DZ
721   FORMAT(
     #          ' LONGITUDINAL DISPERSIVITY = ',1PE10.3' M/YR'/
     #          ' TRANSVERSE   DISPERSIVITY = ',E10.3' M/YR'/
     #          ' VERTICAL     DISPERSIVITY = ',E10.3' M/YR')
C-------------------------------------------------------------
C   SET THE MIXING DEPTH OF THE SATURATED LAYER TO THE DEPTH OF
C      PENETRATION OF THE RECHARGE.  THIS IS CALCULATED AS THE
C      RECHARGE DIVIDED BY SATURATED EFFECTIVE POROSITY.
C-------------------------------------------------------------
      DEPTH = STRC / GWEP
      WRITE (7,727) DEPTH
727   FORMAT (' MIXING DEPTH OF AQUIFER = ',F8.2,' M'
     #          /' MIXING DEPTH = RECHARGE / SATURATED EFFECTIVE POROSITY')
      WRITE (8,812) DEPTH
      WRITE (7,7270)
7270  FORMAT (//41X,'SATURATED'/,26X,'SATURATED',6X,
     #          'DEGRADATION RATE',/,1X,'CONTAMINANT',14X,'KD, L/KG',7X,
     #          'CONSTANT, 1/YR'/)

      DO 32713 II=1,16
      WRITE (7,7271) (CHMNAM(J,II),J=1,5),SAKD(II),SLAMBD(II)
7271  FORMAT (1X,5A4,2(5X,1PE10.3))
         WRITE (8,813) SAKD(II),SLAMBD(II)
32713 CONTINUE
      WRITE (7,728)
728   FORMAT (//' BACKGROUND CONCENTRATIONS OF CONTAMINANTS',
     # ' IN GROUNDWATER'/
     #          ' CONTAMINANT',16X,'CONCENTRATION, MG/L')
      DO 32711 I=1,16
      WRITE (7,729) (CHMNAM(J,I),J=1,5),CBACK(I)
729   FORMAT (1X,5A4,5X,1PE10.2)
      WRITE (8,812) CBACK(I)
32711 CONTINUE
C-----------------------------
C WRITE VAPOR PATHWAY PARAMETERS
C-----------------------------
      WRITE (7,1100) VEL,TEMP,PA,PT,TCA,TCP,XA,STLEN,STWID,
     + ((CHMNAM(J,I),J=1,5),H(I),RMW(I),I=1,16)
1100  FORMAT(/' VAPOR PATHWAY PARAMETERS'/1X,24('-')//
     + ' AVERAGE SURFACE WIND VELOCITY     =',F10.1' M/S'/
     + ' AVERAGE AIR TEMPERATURE           =',F10.1' DEG C'/
     + ' AIR-FILLED POROSITY OF COVER SOIL =',F10.2/
     + ' TOTAL POROSITY OF COVER SOIL      =',F10.2/
     + ' COVER THICKNESS DURING ACTIVITY   =',F10.2' METERS'/
     + ' COVER THICKNESS AFTER CLOSURE     =',F10.2' METERS'/
     + ' CELL LENGTH DURING ACTIVE PERIOD  =',F10.2' METERS'/
     + ' SITE LENGTH                       =',F10.2' METERS'/
     + ' SITE WIDTH                        =',F10.2' METERS'//
     + 3X'CHEMICAL'11X'HENRY''S LAW  MOL WEIGHT'/
     + 1X,20('-'),1X,11('-'),2X,10('-')/(1X,5A4,1PE12.3,0PF10.2))
      WRITE (8,1120) VEL,TEMP,PA,PT,TCA,TCP,XA,(H(I),RMW(I),I=1,16)
     #          ' VERTICAL     DISPERSIVITY = ',E10.3' M/YR')
C-------------------------------------------------------------
C   SET THE MIXING DEPTH OF THE SATURATED LAYER TO THE DEPTH OF
C      PENETRATION OF THE RECHARGE.  THIS IS CALCULATED AS THE
C      RECHARGE DIVIDED BY SATURATED EFFECTIVE POROSITY.
C-------------------------------------------------------------
      DEPTH = STRC / GWEP
      WRITE (7,727) DEPTH
727   FORMAT (' MIXING DEPTH OF AQUIFER = ',F8.2,' M'
     #          /' MIXING DEPTH = RECHARGE / SATURATED EFFECTIVE POROSITY')
      WRITE (8,812) DEPTH
      WRITE (7,7270)
7270  FORMAT (//41X,'SATURATED'/,26X,'SATURATED',6X,
     #          'DEGRADATION RATE',/,1X,'CONTAMINANT',14X,'KD, L/KG',7X,
     #          'CONSTANT, 1/YR'/)

      DO 32713 II=1,16
      WRITE (7,7271) (CHMNAM(J,II),J=1,5),SAKD(II),SLAMBD(II)
7271  FORMAT (1X,5A4,2(5X,1PE10.3))
           WRITE (8,813) SAKD(II),SLAMBD(II)
32713 CONTINUE
      WRITE (7,728)
728   FORMAT (//' BACKGROUND CONCENTRATIONS OF CONTAMINANTS',
     # ' IN GROUNDWATER'/
     #          ' CONTAMINANT',16X,'CONCENTRATION, MG/L')
      DO 32711 I=1,16
      WRITE (7,729) (CHMNAM(J,I),J=1,5),CBACK(I)
729   FORMAT (1X,5A4,5X,1PE10.2)
      WRITE (8,812) CBACK(I)
32711 CONTINUE
C------------------------------
C WRITE VAPOR PATHWAY PARAMETERS
C------------------------------
      WRITE (7,1100) VEL,TEMP,PA,PT,TCA,TCP,XA,STLEN,STWID,
     + ((CHMNAM(J,I),J=1,5),H(I),RMW(I),I=1,16)
1100  FORMAT(/' VAPOR PATHWAY PARAMETERS'/1X,24('-')//
     + ' AVERAGE SURFACE WIND VELOCITY     =',F10.1' M/S'/
     + ' AVERAGE AIR TEMPERATURE           =',F10.1' DEG C'/
     + ' AIR-FILLED POROSITY OF COVER SOIL =',F10.2/
     + ' TOTAL POROSITY OF COVER SOIL      =',F10.2/
     + ' COVER THICKNESS DURING ACTIVITY   =',F10.2' METERS'/
     + ' COVER THICKNESS AFTER CLOSURE     =',F10.2' METERS'/
     + ' CELL LENGTH DURING ACTIVE PERIOD  =',F10.2' METERS'/
     + ' SITE LENGTH                       =',F10.2' METERS'/
     + ' SITE WIDTH                        =',F10.2' METERS'//
     + 3X'CHEMICAL'11X'HENRY''S LAW  MOL WEIGHT'/
     + 1X,20('-'),1X,11('-'),2X,10('-')/(1X,5A4,1PE12.3,0PF10.2))
      WRITE (8,1120) VEL,TEMP,PA,PT,TCA,TCP,XA,(H(I),RMW(I),I=1,16)
```

```
1120  FORMAT(2(F10.2/),2(2F10.2/),F10.2/,(1PE12.3,0PF10.2))
C      WRITE (8,1130) ITER
C1130  FORMAT(I5)
999   CLOSE (7)
      CLOSE (2)
9999  END
```

Appendix BB - Program SLUDGFIX

```
$NOFLOATCALLS
$STORAGE:2
C###################################################################
C   SLUDGFIX.FOR   -   AUG 1988
C
C   SLUDGEMAN AUXILARY PROGRAM TO CHANGE THE INPUT DATA.
C   READS THE INPUT FILE CREATED BY SLUDGIN.FOR AND
C      ALLOWS YOU TO CHANGE THE INPUT DATA IF DESIRED.
C###################################################################
      INTERFACE TO SUBROUTINE TIME (N,STR)
      CHARACTER*10 STR [NEAR,REFERENCE]
      INTEGER*2 N [VALUE]
      END
      INTERFACE TO SUBROUTINE DATE (N,STR)
      CHARACTER*10 STR [NEAR,REFERENCE]
      INTEGER*2 N [VALUE]
      END
      DIMENSION CL(16),CS(16),HC(12),UNHC(5),B(12),THTA(12),EFBD(12),
     #       THIK(5),ADI(16),SAKD(16),SUMUKD(16),SKD(16),ULAMBD(16),
     #       SLAMBD(16),ULAMB(16),SLAMB(16),UNKD(6,12),UKD(16),
     #       CBACK(16),UB(5),UTHTA(5),UEFBD(5)
      REAL KOC(16),FOC(12),H(16),RMW(16),CHEM(54,6)
      INTEGER ITYPE(5),IORGNC(16),NV(6)
      CHARACTER*4 CHMNAM(5,16),SOILID(4,12)
      CHARACTER*10 CHDATE,CHTIME
      CHARACTER*64 INFILE,CASE
C######################################################################
C
C   DATA STATEMENTS
C
C######################################################################
C   16 CONTAMINANTS SIMULATED:
C        6 METALS
C       10 ORGANICS
C---------------------------
      DATA CHMNAM
     # /'ARSE','NIC ','    ','    ','    ',
     #       'CADM','IUM ','    ','    ','    ',
     #       'COPP','ER  ','    ','    ','    ',
     #       'LEAD','    ','    ','    ','    ',
     #       'MERC','URY ','    ','    ','    ',
     #       'NICK','EL  ','    ','    ','    ',
     #       'BENZ','ENE ','    ','    ','    ',
     #       'BENZ','O(A)','PYRE','NE  ','    ',
     #       'BIS(','2ETH','EX)P','THAL','ATE ',
     #       'CHLO','RDAN','E   ','    ','    ',
     #       'DDT/','DDE/','DDD ','    ','    ',
     #       'DIME','THYL','NITR','OSAM','INE ',
     #       'LIND','ANE ','    ','    ','    ',
     #       'PCBS','    ','    ','    ','    ',
     #       'TRIC','HLOR','OETH','YLEN','E   ',
     #       'TOXA','PHEN','E   ','    ','    '/
C-----------------------------
C 12 MATERIAL TYPES SIMULATED.
C-----------------------------
      DATA SOILID
     # /'CLAY','    ','    ','    ','SILT','Y CL','AY  ','    ',
     #       'SILT','Y CL','AY L','OAM ','CLAY',' LOA','M   ','    ',
     #       'SAND','Y CL','AY L','OAM ','SAND','Y SI','LT L','OAM ',
     #       'SILT','Y LO','AM  ','    ','SAND','Y LO','AM  ','    ',
     #       'LOAM','Y SA','ND  ','    ','SAND','    ','    ','    ',
     #       'FRAC','. SA','NDST','ONE ','LIME','STON','E   ','    '/
C---------------------------------------------
C FLAG IDENTIFYING METALS (0) OR ORGANICS (1).
C---------------------------------------------
      DATA IORGNC /0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1/
C------------------------------------------------------------
C HYDRAULIC CONDUCTIVITIES (M/DAY) FOR THE 12 MATERIAL TYPES.
C------------------------------------------------------------
      DATA HC /0.032,0.32,3.2,1.0,3.2,32.0,32.0,100,320.0,3200.0,
     #       1.0,10./
C------------------------------------------------------------------
C 'B' VALUE FOR UNSATURATED ZONE TRAVEL TIME CALCULATION FOR THE 12
C    MATERIAL TYPES.
C 'B' VALUE IS NEGATIVE THE SLOPE OF THE LOG-LOG PLOT OF HEAD VS
C    THETA.
C------------------------------------------------------------------
        DATA B /11.7,9.9,7.5,8.5,7.5,5.4,4.8,6.3,5.6,4.0,4.0,4.0/
C----------------------------------------------
C EFFECTIVE POROSITY FOR THE 12 MATERIAL TYPES.
C----------------------------------------------
      DATA THTA /0.46,0.44,0.42,0.4,0.39,0.38,0.37,0.36,0.35,0.34,
     # 0.01,0.1/
C------------------------------------------------------------
C EFFECTIVE BULK DENSITY FOR THE 12 MATERIAL TYPES (KG/CU M).
C------------------------------------------------------------
      DATA EFBD /1400.,1500.,1500.,1600.,1600.,1600.,1700.,1700.,
     #        1700.,1750.,2620.,2390./
C--------------------------------------------------------------
C ORGANIC CARBON CONSTANT FOR THE 10 ORGANICS (KD = KOC * FOC).
C--------------------------------------------------------------
      DATA KOC /0.,0.,0.,0.,0.,0.,74.,6.3E+05,7244.,1.7E+05,
     #        5.0E+06,0.04,1080.,3.2E+05,198.,960./
C-----------------------------------------------------
C SATURATED DISTRIBUTION COEFFICIENT FOR THE 6 METALS.
C-----------------------------------------------------
```

```
      DATA SAKD /5.86,14.9,41.9,234.0,322.0,12.2,
     #        0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
C-------------------------------------------------------------------
C FRACTION OF ORGANIC CARBON FOR THE 12 SOIL TYPES (KD - KOC * FOC).
C---------------------------------------------------------------------
      DATA FOC /0.01,0.01,0.013,0.01,0.005,0.005,0.001,0.005,0.001,
     #        0.0001,0.0001,0.0001/
C----------------------------------------------------------------
C UNSATURATED LAYER DISTRIBUTION COEFFICIENT FOR THE 8 METALS AND
C    THE 12 MATERIAL TYPES (L/KG).
C----------------------------------------------------------------
      DATA UNKD /19.4,423.,92.2,597.0,580.0,58.6,
     #        19.4,423.,92.2,597.0,580.0,58.6,
     #        19.4,423.,92.2,597.0,580.0,58.6,
     #        19.4,423.,92.2,597.0,580.0,58.6,
     #        19.4,423.,92.2,597.0,580.0,58.6,
     #        19.4,423.,92.2,597.0,580.0,58.6,
     #        19.4,423.,92.2,597.0,580.0,58.6,
     #        19.4,423.,92.2,597.0,580.0,58.6,
     #        5.86,14.9,41.9,234.0,322.0,12.2,
     #        5.86,14.9,41.9,234.0,322.0,12.2,
     #        5.86,14.9,41.9,234.0,322.0,12.2,
     #        5.86,14.9,41.9,234.0,322.0,12.2/
C------------------------------------------------------------------
C   UNSATURATED LAYER DECAY CONSTANT FOR THE 20 CONTAMINANTS (1/T).
C   ANAEROBIC
C------------------------------------------------------------------
      DATA ULAMB /0.,0.,0.,0.,0.,0.,
     #       0.,0.,0.,0.,0.,0.,1.0,0.,0.,0./
C----------------------------------------------------------------
C   SATURATED LAYER DECAY CONSTANT FOR THE 20 CONTAMINANTS (1/T).
C   ANAEROBIC
C----------------------------------------------------------------
      DATA SLAMB /0.,0.,0.,0.,0.,0.,
     #       0.,0.,0.,8.43,.904,607.1,1.0,0.,0.904,0./
C----------------------
C SET SORPTION DATA FOR
C   ARSENIC
C   CADMIUM
C   COPPER
C   LEAD
C   MERCURY
C   NICKEL
C------------------------------------
C READ SORPTION DATA FROM SLUDGE.SORP
C------------------------------------
      OPEN (1,FILE-'SLUDGE.SOR',STATUS-'OLD')
      READ (1,*) NV
      DO 6 I-1,6
      READ (1,*) (CHEM(J,I),J-1,54)
6     CONTINUE
      CLOSE (1)
C     DATA NV / 4,5,4,5,4,4 /
C     DATA CHEM /
C ARSENIC
C    .06,1.27,2.54,5.06,
C     #  1.98E-11,2.29E-11,2.71E-11,4.09E-11,
C     #  2.4E-04,1.06,2.19,4.43,
C     #  2.47E-04,1.19,2.46,5.0,
C     #  5.91E-11,6.83E-11,8.12E-11,1.22E-10,
C     #  6.07E-02,1.27,2.54,5.06,
C     #  6.91E-06,1.19,2.46,4.99,
C     #  5.91E-11,6.83E-11,8.12E-11,1.22E-10,
C     #  6.07E-02,1.27,2.54,5.06,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C CADMIUM
C     # .01,.125,.250,.499,49.9,
C     # .0101,.125,.250,.499,49.5,
C
C     # .01,.123,.248,.498,49.9,
C     # .0083,.118,.181,.266,49.4,
C     # .01,.125,.183,.268,49.4,
C     #
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C COPPER
C     #  1.32,32.5,65.4,130.,
C     #  1.58E-08,2.0E-07,2.04E-07,2.04E-07,
C     #  0.162,0.162,0.162,0.162,
C     #  1.09,3.08,3.15,3.34,
C     #  7.88E-07,1.9E-06,1.9E-06,1.9E-06,
C     #  0.15,0.15,0.15,0.15,
C     #  0.269,0.267,0.265,0.262,
C     #  7.88E-07,1.9E-06,1.9E-06,1.9E-06,
C     #  0.15,0.15,0.15,0.15,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C MERCURY
C     #  0.03,0.499,1.0,2.0,10.,
C     #  2.01E-11, 2.03E-11, 2.05E-11, 2.09E-11, 4.02E-11,
C     #  1.36E-07,    0.402, 0.901, 1.9,  9.89,
C     #  1.35E-07,    0.402, 0.901, 1.9,  9.89,
C     #  2.41E-12, 2.43E-12, 2.46E-12, 2.50E-12, 2.96E-11,
C     #  1.06E-07,    0.402, 0.901, 1.9,  9.89,
C     #  1.05E-07,    0.402, 0.901, 1.9,  9.67,
C     #  2.41E-12, 2.43E-12, 2.46E-12, 2.50E-12, 2.96E-11,
C     #  1.06E-07,    0.402, 0.901, 1.9,  9.89,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C LEAD
C     #  3.51E-03,7.52E-02,0.15,0.301,
C     #  4.59E-07,4.61E-07,4.61E-07,4.63E-07,
C     #  1.75E-03,2.43E-02,2.43E-02,2.43E-02,
C     #  3.41E-03,6.82E-02,   0.137,   0.243,
C     #  6.86E-08,6.86E-08,6.86E-08,6.86E-08,
C     #  1.83E-03,2.43E-02,2.43E-02,2.43E-02,
C     #  2.13E-04,2.13E-04,2.13E-04,2.13E-04,
C     #  6.86E-08,6.86E-08,6.86E-08,6.86E-08,
C     #  1.83E-03,2.43E-02,2.43E-02,2.43E-02,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C NICKEL
C     #  .159,3.75,7.46,15.0,
C     #  4.3E-05,5.65E-05,8.4E-05,3.22E-03,
C     #  0.16,3.75,7.51,15.0,
C     #  0.16,3.75,7.51,15.0,
C     #  4.33E-06,5.69E-06,8.45E-06,3.45E-04,
C     #  0.16,3.75,7.51,15.0,
C     #  0.16,3.75,7.51,15.0,
C     #  4.33E-06,5.69E-06,8.45E-06,3.45E-04,
C     #  0.16,3.75,7.51,15.0,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,
C     #  0.,0.,0.,0.,0.,0.,0.,0.,0.,/

C#####################################################################
C
C   BEGIN MAIN PROGRAM
C
C#####################################################################
C-----------------------------------------------------------
C OPEN 2: SLUDGIN.OUT - PRIMARY INPUT DATA FILE
C      7: SLUDGFIX.DES - CORRECTED OUTPUT FILE WITH EXPLANATIONS
C      8: SLUDGFIX.OUT - CORRECTED INPUT FILE TO SLUGMAIN
C-----------------------------------------------------------
      OPEN (2,FILE='SLUDGIN.OUT',STATUS='OLD',FORM='FORMATTED')
      OPEN (7,FILE='SLUDGFIX.DES',STATUS='NEW')
      OPEN (8,FILE='SLUDGFIX.OUT',STATUS='NEW')
C#####################################################################
C
C
C   READ THE INPUT DATA FILE (SLUDGE.TMP) CREATED BY SLUDGIN.FLX.
C
C
C#####################################################################
C--------------------
```

```
C READ IN NAME OF CASE
C---------------------
      READ (2,'(A)') CASE
C-----------------------------------
C READ IN CONTAMINANT CONCENTRATIONS
C-----------------------------------
      DO 32758 I=1,16
      READ (2,*) CL(I),CS(I),ADI(I)
32758 CONTINUE
C--------------------
C READ IN SLUDGE DATA
C--------------------
      READ (2,*) SLMC
      READ (2,*) SLSC
      READ (2,*) SLDN
C------------------
C READ IN SITE DATA
C------------------
      READ (2,*) STRC
      READ (2,*) STDB
      READ (2,*) STWID
      READ (2,*) STLEN
      READ (2,*) FLHT
      READ (2,*) UDX
C------------------------------
C READ IN UNSATURATED ZONE DATA
C------------------------------
      STDG = 0.
      READ (2,*) NLAYRS
      DO 32757 I=1,NLAYRS
      READ (2,*) ITYPE(I)
      READ (2,*) THIK(I)
      STDG = STDG + THIK(I)
      READ (2,*) UNHC(I)
      READ (2,*) UB(I)
      READ (2,*) UTHTA(I)
      READ (2,*) UEFBD(I)
32757 CONTINUE
      DO 32756 I=1,16
      READ (2,*) UKD(I),ULAMBD(I)
32756 CONTINUE
C----------------------------
C READ IN SATURATED ZONE DATA
C----------------------------
      READ (2,*) IPHEH
      READ (2,*) ISATYP
      READ (2,*) GWHC
      READ (2,*) GWEP
      READ (2,*) GWGR
      READ (2,*) GWEBD
      READ (2,*) AQDEP
      READ (2,*) AQWID
      READ (2,*) DX,DY,DZ
      READ (2,*) DEPTH
      DO 32755 I=1,16
      READ (2,*) SKD(I),SLAMBD(I)
32755 CONTINUE
      DO 32754 I=1,16
      READ (2,*) CBACK(I)
32754 CONTINUE
C---------------------
C READ VAPOR PARAMETERS
C---------------------
      READ (2,8) VEL,TEMP,PA,PT,TCA,TCP,XA,(H(I),RMW(I),I=1,16)
8     FORMAT(2(F10.2/),2(2F10.2/),F10.2/,(E12.3,F10.2))
      READ (2,*) ITER
      CLOSE (UNIT=2)
C#########=#########################################################=====
C
C
C CHANGE ORIGINAL INPUT FILE IF DESIRED
C
C
C#########=#########################################################=====
1     WRITE (*,10)
10    FORMAT (//14X,'PROGRAM:  SLUDGFIX'/
     #       /'    THIS PROGRAM ALLOWS THE USER TO MAKE CHANGES TO THE'
     #       /' MODEL INPUT DATA.  THE USER CAN CHANGE DATA BASED ON'
     #       /' CATEGORY. THE DATA CATEGORIES ARE:'/
     #       /'            0) EXIT "SLUDGFIX",'
     #       /'            1) CASE NAME,'
     #       /'            2) CHANGE CONTAMINANT NAME,'
     #       /'            3) CONTAMINANT CONCENTRATION DATA,'
     #       /'            4) SLUDGE DATA,'
     #       /'            5) SITE DATA,'
     #       /'            6) UNSATURATED ZONE DATA,'
     #       /'            7) SATURATED ZONE DATA,'
     #       /'            8) UNSAT/SAT PARTITION COEFFICIENTS (KD''S)'
     #       /'            9) CONTAMINANT DEGRADATION DATA,'
     #       /'           10) BACKGROUND CONCENTRATIONS,'
     #       /'           11) EFFECTS THRESHOLD VALUES,'
     #       /'           12) VAPOR PARAMETERS,'
     #       /' SELECT A CATEGORY'/)

C    #       /'           13) BACK-CALCULATE ALLOWABLE INPUT
CONC''S'/ C       READ(*,*,ERR=1) ISLECT
```

```
C-----------------------------------------
C EXIT THE MENU & WRITE OUT THE SLUDGE.FIL FILE
C-----------------------------------------
      IF (ISLECT.EQ.0) GO TO 8000
      IF((1).NE.(ISLECT)) GO TO 32752
C-----------------
C  CHANGE CASE NAME
C-----------------
      WRITE (*,20)
20    FORMAT (/' THE CURRENT DESCRIPTOR LINE AT THE TOP OF THE INPUT'
     #        ' FILE IS:')
      WRITE (*,30) CASE
30    FORMAT (/,1X,A64,//)
40    WRITE (*,50)
50    FORMAT (' DO YOU WANT TO CHANGE THE CASE DESCRIPTOR LINE?'
     #        ' (Y=1, N=<CR>)')
      READ (*,60,ERR=40) ICASE
60    FORMAT (I2)
      IF(.NOT.(ICASE .NE. 0)) GO TO 32751
      WRITE (*,70)
70    FORMAT (/' ENTER THE NEW CASE DESCRIPTOR')
      READ (*,'(A)') CASE
32751 GO TO 1
32752 IF (ISLECT.EQ.2) THEN
C--------------------------------------------
C  CHANGE CONTAMINANT NAME (ADD NEW CONTAMINANTS)
C--------------------------------------------
      WRITE (*,501)
501   FORMAT (/9X,' ***  ADD NEW CONTAMINANTS  ***',//
     #        4X,'THIS SECTION ALLOWS THE USER TO REPLACE UNUSED'/
     # ' CONTAMINANTS WITH CONTAMINANTS WHICH MAY BE DESIRED'/
     # ' BUT WHICH ARE NOT CURRENTLY AVAILABLE IN THE LIST.'/
     # ' WHEN REPLACING A CONTAMINANT, A METAL SHOULD REPLACE'/
     # ' A METAL, AND AN ORGANIC SHOULD REPLACE AN ORGANIC.'/)
      WRITE (*,*)' PRESS <CR> WHEN READY TO PROCEED'
      READ (*,5010) IGO
5010  FORMAT(I5)
5011  WRITE (*,5012)
5012  FORMAT (/'    THE CURRENT CHEMICAL LIST IS:'/)
      DO 5013 I=1,15,2
      II = I + 1
      WRITE (*,502) I,(CHMNAM(J,I),J=1,5),II,(CHMNAM(J,II),J=1,5)
5013  CONTINUE
502   FORMAT(2(I5,')',1X,5A4))
503   WRITE (*,504)
504   FORMAT (/' ENTER THE "NUMBER" OF THE CONTAMINANT YOU WISH TO',
     # ' REPLACE.'/' BE SURE TO REPLACE METALS WITH METALS',
     # ' AND ORGANICS WITH ORGANICS.'/' ENTER "0" TO EXIT.'/)
```

```
      READ (*,5010,ERR=503) ICHNUM
      IF (ICHNUM.EQ.0) GO TO 515
      IF (ICHNUM.LT.1.OR.ICHNUM.GT.19) GO TO 503
      WRITE (*,505) (CHMNAM(K,ICHNUM),K=1,5)
505   FORMAT (' YOU ARE REPLACING CONTAMINANT ',5A4,/
     # ' ENTER THE NEW CONTAMINANT NAME TO REPLACE IT.'/
     # ' (MAXIMUM OF 20 CHARACTERS)'/)
      READ (*,506,ERR=503) (CHMNAM(K,ICHNUM),K=1,5)
506   FORMAT (5A4)
C--------------------------------------------
C IF A METAL, ENTER NEW SORPTION (MINTEQ) DATA
C--------------------------------------------
      IF(.NOT.(ICHNUM.GT.0 .AND. ICHNUM.LT.7)) GO TO 5011
      NV0 = NV(ICHNUM)
      IF (NV0.EQ.0) NV0 = 6

      WRITE (*,5074) (CHMNAM(K,ICHNUM),K=1,5),
     # (CHEM(J,ICHNUM),J=1,NV0)
5074  FORMAT(//' CHEMICAL SORPTION DATA FOR ',5A4//
     # 23X'PRIOR TO SORPTION: (MG/L)'/15X,64('-')/
     # 13X,1P6E11.3/)

      NV1 = NV0 + 1
      NV2 = NV0 + NV0
      WRITE (*,5075) (CHEM(J,ICHNUM),J=NV1,NV2)
5075  FORMAT(/23X'AFTER SORPTION: (MG/L)'/15X,64('-')/
     # ' PH=6 EH=-200',1P6E11.3)

      NV1 = NV2 + 1
      NV2 = NV2 + NV0
      WRITE (*,5076) (CHEM(J,ICHNUM),J=NV1,NV2)
5076  FORMAT(' PH=6 EH=+150',1P6E11.3)

      NV1 = NV2 + 1
      NV2 = NV2 + NV0
      WRITE (*,5077) (CHEM(J,ICHNUM),J=NV1,NV2)
5077  FORMAT(' PH=6 EH=+500',1P6E11.3)

      NV1 = NV2 + 1
      NV2 = NV2 + NV0
      WRITE (*,5078) (CHEM(J,ICHNUM),J=NV1,NV2)
5078  FORMAT(' PH=7 EH=-200',1P6E11.3)

      NV1 = NV2 + 1
      NV2 = NV2 + NV0
      WRITE (*,5079) (CHEM(J,ICHNUM),J=NV1,NV2)
5079  FORMAT(' PH=7 EH=+150',1P6E11.3)
```

```
      NV1 - NV2 + 1
      NV2 - NV2 + NVO
      WRITE (*,5080) (CHEM(J,ICHNUM),J-NV1,NV2)
5080  FORMAT(' PH-7 EH-+500',1P6E11.3)

      NV1 - NV2 + 1
      NV2 - NV2 + NVO
      WRITE (*,5081) (CHEM(J,ICHNUM),J-NV1,NV2)
5081  FORMAT(' PH-8 EH--206',1P6E11.3)

      NV1 - NV2 + 1
      NV2 - NV2 + NVO
      WRITE (*,5082) (CHEM(J,ICHNUM),J-NV1,NV2)
5082  FORMAT(' PH-8 EH-+106',1P6E11.3)

C       IF (NVO.EQ.5) THEN
C       WRITE (*,5075) (CHMNAM(K,ICHNUM),K-1,5),
C     # (CHEM(J,ICHNUM),J-1,45)
C5075   FORMAT(//' CHEMICAL SORPTION DATA FOR ',5A4//
C     # 28X'PRIOR TO SORPTION:'/15X,53('-')/
C     # 13X,1P5E11.3//28X'AFTER SORPTION:'/15X,53('-')/
C     # ' PH-6 EH--200',5E11.3/' PH-6 EH-+150',5E11.3/
C     # ' PH-6 EH-+500',5E11.3/' PH-7 EH--200',5E11.3/
C     # ' PH-7 EH-+150',5E11.3/' PH-7 EH-+500',5E11.3/
C     # ' PH-8 EH--206',5E11.3/' PH-8 EH-+106',5E11.3/)
C       END IF
C       IF (NVO.EQ.6) THEN
C       WRITE (*,5076) (CHMNAM(K,ICHNUM),K-1,5),
C     # (CHEM(J,ICHNUM),J-1,54)
C5076   FORMAT(//' CHEMICAL SPECIATION DATA FOR ',5A4//
C     # 34X'PRIOR TO SORPTION:'/15X,64('-')/
C     # 13X,1P6E11.3//34X'AFTER SORPTION:'/15X,64('-')/
C     # ' PH-6 EH--200',6E11.3/' PH-6 EH-+150',6E11.3/
C     # ' PH-6 EH-+500',6E11.3/' PH-7 EH--200',6E11.3/
C     # ' PH-7 EH-+150',6E11.3/' PH-7 EH-+500',6E11.3/
C     # ' PH-8 EH--206',6E11.3/' PH-8 EH-+106',6E11.3/)

C       END IF
      WRITE(*,508)
508   FORMAT(/' DO YOU WISH TO CHANGE THIS SORPTION DATA?',
     # ' (1-YES, <CR>-USE THIS DATA)')
      READ (*,5010) IYN
      IF (IYN.EQ.0) GO TO 5011
      WRITE(*,509)
509   FORMAT(' ENTER NUMBER OF INPUT CONCENTRATION VALUES (6 MAX)')
      READ(*,*) NV2
      IF (NV2.GT.6) NV2 - 6
      NV(ICHNUM) - NV2
      WRITE(*,510) NV2
510   FORMAT(' ENTER',I3,' INPUT CONCENTRATIONS SEPARATED BY COMMAS'
     # ,' (MOL/L)')
      READ(*,*) (CHEM(J,ICHNUM),J=1,NV2)
      WRITE(*,511) NV2,6,-200
511   FORMAT(' ENTER',I2,' VALUES FOR PH='I1', EH='I4)
      READ(*,*) (CHEM(J,ICHNUM),J=NV2+1,2*NV2)
      WRITE(*,511) NV2,6,150
      READ(*,*) (CHEM(J,ICHNUM),J=2*NV2+1,3*NV2)
      WRITE(*,511) NV2,6,500
      READ(*,*) (CHEM(J,ICHNUM),J=3*NV2+1,4*NV2)
      WRITE(*,511) NV2,7,-200
      READ(*,*) (CHEM(J,ICHNUM),J=4*NV2+1,5*NV2)
      WRITE(*,511) NV2,7,150
      READ(*,*) (CHEM(J,ICHNUM),J=5*NV2+1,6*NV2)
      WRITE(*,511) NV2,7,500
      READ(*,*) (CHEM(J,ICHNUM),J=6*NV2+1,7*NV2)
      WRITE(*,511) NV2,8,-206
      READ(*,*) (CHEM(J,ICHNUM),J=7*NV2+1,8*NV2)
      WRITE(*,511) NV2,8,106
      READ(*,*) (CHEM(J,ICHNUM),J=8*NV2+1,9*NV2)
      GO TO 5011
515   WRITE (*,516)
516   FORMAT (' NOW THAT YOU HAVE REPLACED A CONTAMINANT(S),'/
     # ' YOU MAY DESIRE TO REENTER THE CHEMICAL CHARACTERISTICS'/
     # ' LISTED IN ITEMS 3, 8, 9, 10, 11, & 12 IN THE MAIN MENU.'/)
      WRITE (*,*) 'ENTER <CR> WHEN READY TO PROCEED'
      READ (*,5010,ERR=515) IGO
      GO TO 1
      END IF
      IF (3.NE.ISLECT) GO TO 32750
C-----------------------------
C CONTAMINANT CONCENTRATION DATA
C-----------------------------
80    WRITE (*,85)
85    FORMAT (/' EXISTING CONTAMINANT CONCENTRATION DATA:'//
     #        1X,'INDEX',2X,'CONTAMINANT',10X,'CL, MG/L',4X,'CS, MG/KG'/)
      DO 32749 I=1,16
      WRITE (*,90) I,(CHMNAM(J,I),J=1,5),CL(I),CS(I)
90    FORMAT (1X,I5,2X,5A4,2(2X,1PE10.4))
32749 CONTINUE
      WRITE (*,100)
100   FORMAT (/' ENTER INDEX NUMBER OF CONTAMINANT WHOSE'/
     #           ' CONCENTRATION YOU WANT TO CHANGE OR ENTER 0 TO QUIT')
      READ (*,60,ERR=80) INDX
      IF (INDX .EQ. 0) GO TO 1
      IF ((INDX .LT. 0) .OR. (INDX .GT. 16)) GOTO 80
105   WRITE (*,110) (CHMNAM(J,INDX),J=1,5),CL(INDX)
```

```
110   FORMAT (/,' EXISTING LIQUID CONCENTRATION OF ',5A4,' IS ',
     #        1PE10.3,/' ENTER NEW VALUE')
      READ (*,120,ERR-105) RCL
120   FORMAT (F15.0)
      CL(INDX) - RCL
125   WRITE (*,130) (CHMNAM(J,INDX),J-1,5),CS(INDX)
130   FORMAT (/,' EXISTING SOLID CONCENTRATION OF ',5A4,' IS ',
     #        1PE10.3,/' ENTER NEW VALUE')
      READ (*,120,ERR-125) RCS
      CS(INDX) - RCS
      GOTO 80
32750 IF((4).NE.(ISLECT)) GO TO 32747
C------------
C SLUDGE DATA
C------------
140   WRITE (*,704) SLMC
      WRITE (*,150)
150   FORMAT (/' ENTER NEW SLUDGE MOISTURE CONTENT (CU M/CU M)'/
     #       ' <CR> - NO CHANGE')
      READ (*,120,ERR-140) SLMCN
      IF (SLMCN.NE.0) SLMC - SLMCN
C
160   WRITE (*,705) SLSC
      WRITE (*,170)
170   FORMAT (/' ENTER NEW SLUDGE STORAGE CAPACITY (CU M/CU M)')
      READ (*,120,ERR-160) SLSCN
      IF (SLSCN.NE.0) SLSC - SLSCN
C
180   WRITE (*,706) SLDN
      WRITE (*,190)
190   FORMAT (/' ENTER NEW SLUDGE DENSITY (CU M/CU M)')
      READ (*,120,ERR-180) SLDNN
      IF (SLDNN.NE.0) SLDN - SLDNN
      GO TO 1
32747 IF((5).NE.(ISLECT)) GO TO 32746
C----------
C SITE DATA
C----------
200   WRITE (*,708) STRC
      WRITE (*,210)
210   FORMAT (/' ENTER NEW (OR <CR>) NET RECHARGE (M/YR)')
      READ (*,120,ERR-200) STRCN
      IF (STRCN.NE.0) STRC - STRCN
C
220   WRITE (*,710) STDB
      WRITE (*,230)
230   FORMAT (/' ENTER NEW (OR <CR>) DISTANCE FROM LANDFILL'
     #       ' BOUNDARY TO MONITORING LOCATION (M)')
```

```
      READ (*,120,ERR=220) STDBN
      IF (STDBN.NE.0) STDB = STDBN
C
240   WRITE (*,250) STWID
250   FORMAT (//' THE OLD LANDFILL WIDTH (M) =', F8.2)
      WRITE (*,260)
260   FORMAT (/' ENTER A NEW (OR <CR>) LANDFILL WIDTH (M)')
      READ (*,120,ERR=240) STWIDN
      IF (STWIDN.NE.0) STWID = STWIDN
C
270   WRITE (*,280) STLEN
280   FORMAT (//' THE OLD LANDFILL LENGTH (M) =', F8.2)
      WRITE (*,290)
290   FORMAT (/' ENTER A NEW (OR <CR>) LANDFILL LENGTH (M)')
      READ (*,120,ERR=270) STLENN
      IF (STLENN.NE.0) STLEN = STLENN
C
300   WRITE (*,310) FLHT
310   FORMAT (//' THE OLD FILL HEIGHT (M)=', F8.2)
      WRITE (*,320)
320   FORMAT (/' ENTER A NEW (OR <CR>) FILL HEIGHT')
      READ (*,120,ERR=300) FLHTN
      IF (FLHTN.NE.0) FLHT = FLHTN
      GO TO 1
32746 IF((6).NE.(ISLECT)) GO TO 32745
C-----------------------
C   UNSATURATED ZONE DATA
C-----------------------
330   WRITE (*,340) UDX
340   FORMAT(/' THE OLD UNSATURATED ZONE DISPERSIVITY (M) =',1PE10.2)
      WRITE (*,350)
350   FORMAT(' ENTER A NEW DISPERSIVITY (OR <CR> TO RETAIN VALUE')
      READ (*,120,ERR=330) UDXN
      IF (UDXN.NE.0) UDX = UDXN
C
1123  WRITE (*,918) NLAYRS
918   FORMAT (/1X, 'NUMBER OF UNSATURATED SOIL LAYERS =', I5)
      WRITE (*,919)
919   FORMAT (/' ENTER NEW (OR <CR>) NO. OF UNSATURATED SOIL LAYERS')
      READ (*,60,ERR=1123) NLAYER
      IF (NLAYER.NE.0) NLAYRS = NLAYER
C
      DO 32744 I = 1,NLAYRS
1124  WRITE (*,920)
920    FORMAT (/' MATERIAL TYPES FOR UNSATURATED ZONE',
     #          /'  1 = CLAY'
     #          /'  2 = SILTY CLAY'
     #          /'  3 = SILTY CLAY LOAM'
```

```
    #        /'  4 = CLAY LOAM'
    #        /'  5 = SANDY CLAY LOAM'
    #        /'  6 = SANDY SILT LOAM'
    #        /'  7 = SILTY LOAM'
    #        /'  8 = SANDY LOAM'
    #        /'  9 = LOAMY SAND'
    #        /' 10 = SAND'
    #        /' 11 = FRACTURED SANDSTONE'
    #        /' 12 = FRACTURED LIMESTONE')
      WRITE (*,921) I,ITYPE(I)
921   FORMAT (/' OLD MATERIAL NUMBER FOR LAYER ',I5,' WAS',I5)
      WRITE (*,922)
922   FORMAT (/' ENTER NEW (OR <CR>) MATERIAL NUMBER')
      READ (*,60,ERR=1124) ITYPI
      IF(.NOT.(ITYPI.NE.0)) GO TO 32743
      ITYPE(I) = ITYPI
      UNHC(I) = HC(ITYPE(I))
      UB(I) = B(ITYPE(I))
      UTHTA(I) = THTA(ITYPE(I))
      UEFBD(I) = EFBD(ITYPE(I))
C
32743 CONTINUE
1127  WRITE (*,924) I,THIK(I)
924   FORMAT (/' THE OLD THICKNESS FOR LAYER ',I5,' WAS',F8.2)
      WRITE (*,925)
925   FORMAT (/' ENTER NEW (OR <CR>) THICKNESS')
      READ (*,120,ERR=1127) THIKI
      IF (THIKI.NE.0) THIK(I) = THIKI
C
1125  WRITE (*,933) UNHC(I)
      WRITE (*,934)
      READ (*,60,ERR=1125) IFLG
      IF(.NOT.(IFLG.NE.0)) GO TO 32742
1126  WRITE (*,923)
923   FORMAT (/' ENTER A NEW HYDRAULIC CONDUCTIVITY (M/YR)')
      READ (*,*,ERR=1126) UNHC(I)
C
32742 CONTINUE
1187  WRITE (*,983) UB(I)
983   FORMAT (//' THE EXISTING SLOPE OF SOIL MOISTURE CURVE '
    #      /' ("B VALUE") FOR THIS MATERIAL IS ',F10.4)
      WRITE (*,934)
      READ (*,60,ERR=1187) IFLG
      IF(.NOT.(IFLG.NE.0)) GO TO 32741
1184  WRITE (*,984)
984   FORMAT (/' ENTER A NEW "B VALUE"')
      READ (*,*,ERR=1184) UB(I)
C
```

```
32741 CONTINUE
1197  WRITE (*,993) UTHTA(I)
993   FORMAT (//' THE EXISTING VALUE OF EFFECTIVE POROSITY'
     #       /' FOR THIS MATERIAL IS ',F10.3,' CU M/CU M')
      WRITE (*,934)
      READ (*,60,ERR-1197) IFLG
      IF(.NOT.(IFLG.NE.0)) GO TO 32740
1194  WRITE (*,994)
994   FORMAT (/' ENTER A NEW EFFECTIVE POROSITY (CU M/CU M)')
      READ (*,*,ERR-1194) UTHTA(I)
C
32740 CONTINUE
1177  WRITE (*,963) UEFBD(I)
963   FORMAT (//' THE EXISTING VALUE OF EFFECTIVE BULK '
     #       /' DENSITY FOR THIS MATERIAL IS ',F10.3,' KG/CU M')
      WRITE (*,934)
      READ (*,60,ERR-1177) IFLG
      IF(.NOT.(IFLG.NE.0)) GO TO 32739
1164  WRITE (*,964)
964   FORMAT (/' ENTER A NEW EFFECTIVE BULK DENSITY (KG/CU M)')
      READ (*,*,ERR-1164) UEFBD(I)
C
32739 CONTINUE
32744 CONTINUE
C
      WRITE (*,9251)
9251  FORMAT (/' NOTICE: CHANGING UNSATURATED ZONE DATA MAY'/
     #          '         RESULT IN CHANGES TO THE UNSATURATED'/
     #          '         ZONE KD VALUES.'/)
      TTHIK - 0.
      DO 32738 K-1,16
      SUMUKD(K) - 0.
32738 CONTINUE
      DO 32737 I-1,NLAYRS
C--------------------------------------------------
C   CALCULATE TOTAL THICKNESS,
C--------------------------------------------------
      TTHIK - TTHIK + THIK(I)
C-----------------------------------------------------
C   CALCULATE KD'S FOR THE ORGANICS AS KOC TIMES FOC.
C-----------------------------------------------------
      DO 32736 L-1,16
      IF(.NOT.(IORGNC(L) .EQ. 1)) GO TO 32735
      SUMUKD(L) - SUMUKD(L) + (KOC(L) * FOC(ITYPE(I)) * THIK(I))
C-------------------------------
C   SET THE KD'S FOR THE METALS.
C-------------------------------
32735 IF(.NOT.(IORGNC(L) .EQ. 0)) GO TO 32734
```

```
      SUMUKD(L) - SUMUKD(L) + (UNKD(L,ITYPE(I)) * THIK(I))
32734 CONTINUE
32736 CONTINUE
32737 CONTINUE
      STDG - TTHIK
      GO TO 1
32745 IF((7).NE.(ISLECT)) GO TO 32733
C-------------------
C SATURATED ZONE DATA
C-------------------
1128  WRITE (*,927) IPHEH
927   FORMAT (/' THE PH (SU) AND EH (MV) CATEGORIES ARE AS FOLLOWS:'
     #       /'          1 - PH 6.0, EH -200',
     #       /'          2 - PH 6.0, EH +150',
     #       /'          3 - PH 6.0, EH +500',
     #       /'          4 - PH 7.0, EH -200',
     #       /'          5 - PH 7.0, EH +150',
     #       /'          6 - PH 7.0, EH +500'//
     #        ' THE OLD PH AND EH CATEGORY SELECTED WAS',I3//
     #        ' ENTER A NEW PH-EH CATEGORY, OR <CR> TO USE OLD VALUE.'/
     #        ' TO BE CONSERVATIVE, SELECT THE LOWER PH VALUE AND THE'/
     #        ' HIGHER EH VALUE.')
      READ (*,60,ERR-1128) IPHEHN
      IF(.NOT.(IPHEHN.NE.0)) GO TO 32732
      IF(.NOT.(IPHEHN.LT.1 .OR. IPHEHN.GT.6)) GO TO 32731
      WRITE (*,1129)
1129  FORMAT(/' ** SELECTED VALUE IS OUTSIDE THE RANGE OF 1 TO 6'
     #       ' **'/' PLEASE SELECT AGAIN')
      GO TO 1128
32731 IPHEH - IPHEHN
32732 CONTINUE
1130  WRITE (*,930)
C
930     FORMAT (//' THE SATURATED ZONE MATERIAL TYPES ARE',
     #          /'  1 - CLAY'
     #          /'  2 - SILTY CLAY'
     #          /'  3 - SILTY CLAY LOAM'
     #          /'  4 - CLAY LOAM'
     #          /'  5 - SANDY CLAY LOAM'
     #          /'  6 - SANDY SILT LOAM'
     #          /'  7 - SILTY LOAM'
     #          /'  8 - SANDY LOAM'
     #          /'  9 - LOAMY SAND'
     #          /' 10 - SAND'
     #          /' 11 - FRACTURED SANDSTONE'
     #          /' 12 - FRACTURED LIMESTONE'/)
99    WRITE (*,931) ISATYP
931   FORMAT (/' THE OLD SATURATED ZONE MATERIAL TYPE WAS',I3)
```

```
      WRITE (*,932)
932   FORMAT (/' ENTER A NEW SATURATED ZONE MATERIAL TYPE (OR <CR>)')
      READ (*,60,ERR-1130) INEW
      IF(.NOT.(INEW.NE.0)) GO TO 32730
      ISATYP - INEW
      GWHC - HC(ISATYP)
32730 CONTINUE
1131  WRITE (*,933) GWHC
933   FORMAT (//' THE EXISTING VALUE OF SATURATED HYDRAULIC '
     #        /' CONDUCTIVITY FOR THIS MATERIAL IS ',F10.3,' M/YR')
      WRITE (*,934)
934   FORMAT (/' DO YOU WANT TO ENTER A DIFFERENT VALUE? (Y-1, N-CR)')
      READ (*,60,ERR-1131) IFLG
      IF(.NOT.(IFLG.NE.0)) GO TO 32729
1132  WRITE (*,935)
935   FORMAT (/' ENTER A NEW AQUIFER HYDRAULIC CONDUCTIVITY (M/YR)')
      READ (*,*,ERR-1132) GWHC
C
32729 CONTINUE
1133  WRITE (*,936) GWEP
936   FORMAT (//' THE OLD SATURATED EFFECTIVE POROSITY -', F8.2)
      WRITE (*,937)
937   FORMAT (/' ENTER A NEW (OR <CR>) EFFECTIVE POROSITY')
      READ (*,120,ERR-1133) GWEPN
      IF (GWEPN.NE.0) GWEP - GWEPN
C
1134  WRITE (*,938) GWGR
938   FORMAT (//' THE OLD AQUIFER HYDRAULIC GRADIENT (M/M) -',E10.4)
      WRITE (*,939)
939   FORMAT (/' ENTER A NEW (OR <CR>) HYDRAULIC GRADIENT')
      READ (*,120,ERR-1134) GWGRN
      IF (GWGRN.NE.0) GWGR - GWGRN
C
1135  WRITE (*,940) GWEBD
940   FORMAT (//' THE OLD EFFECTIVE BULK DENSITY (KG/CU M) -',F8.2)
      WRITE (*,941)
941   FORMAT (/' ENTER A NEW (OR <CR>) EFFECTIVE BULK DENSITY')
      READ (*,120,ERR-1135) GWEBDN
      IF (GWEBDN.NE.0) GWEBD - GWEBDN
C
1136  WRITE (*,942) AQDEP
942   FORMAT (//' THE OLD AQUIFER DEPTH (M) -', F8.2)
      WRITE (*,943)
943   FORMAT (/' ENTER A NEW (OR <CR>) AQUIFER DEPTH (M)')
      READ (*,120,ERR-1136) AQDEPN
      IF (AQDEPN.NE.0) AQDEP - AQDEPN
C
1137  WRITE (*,944) AQWID
```

```
944   FORMAT (//' THE OLD AQUIFER WIDTH (M) -', 1PE12.2//
     #        ' ENTER A NEW AQUIFER WIDTH (M) (PERPENDICULAR TO THE',
     #        ' FLOW PATH)'/' OR <CR> TO USE PREVIOUS VALUE')
      READ (*,120,ERR-1137) AQWIDN
      IF (AQWIDN.NE.0) AQWID - AQWIDN
C
C
1010  WRITE (*,1020) DX
1020  FORMAT (//' THE OLD LONGITUDINAL DISPERSIVITY (M) -',1PE10.2)
      WRITE (*,1030)
1030  FORMAT (/' ENTER A NEW LONG. DISPERSIVITY (OR <CR>) (M)')
      READ (*,120,ERR-1010) DXN
      IF (DXN.NE.0) DX - DXN
1040  WRITE (*,1050) DY
1050  FORMAT (//' THE OLD LATERAL DISPERSIVITY (M) -',1PE10.2)
      WRITE (*,1060)
1060  FORMAT (/' ENTER A NEW LATERAL DISPERSIVITY (OR <CR>) (M)')
      READ (*,120,ERR-1040) DYN
      IF (DYN.NE.0) DY - DYN
1070  WRITE (*,1080) DZ
1080  FORMAT (//' THE OLD VERTICAL DISPERSIVITY (M) -',1PE10.2)
      WRITE (*,1090)
1090  FORMAT (/' ENTER A NEW VERTICAL DISPERSIVITY (OR <CR>) (M)')
      READ (*,120,ERR-1070) DZN
      IF (DZN.NE.0) DZ - DZN
      WRITE (*,1100)
1100  FORMAT (/' NOTICE: CHANGING SATURATED ZONE DATA MAY'/
     #          '          RESULT IN CHANGES TO THE SATURATED'/
     #          '          ZONE KD VALUES.'/)
C--------------------------
C  SET NEW SATURATED ZONE KDS
C--------------------------
      DO 32728 I-1,16
      SKD(I) = SAKD(I)
32728 CONTINUE
      GO TO 1
32733 IF((8).NE.(ISLECT)) GO TO 32727
C----------------------------
C  CONTAMINANT ATTENUATION DATA
C----------------------------
C
C-----------------------
C   CHANGE UNSATURATED KDS
C-----------------------
1110  WRITE (*,1120)
1120  FORMAT (/' ***** ""UNSATURATED"" ZONE KD  *****    '//
     #        ' EXISTING UNSATURATED KD VALUES ARE:'/
     #           2X,'#',2X,'CONTAMINANT',12X,'KD (L/KG) ',
     #          6X,'#',2X,'CONTAMINANT',12X,'KD (L/KG)'/)
      DO 32726 I=1,15,2
      II = I + 1
      WRITE (*,9471) I,(CHMNAM(J,I),J=1,5),UKD(I),
     # II,(CHMNAM(J,II),J=1,5),UKD(II)
9471  FORMAT (I3,2X,5A4,2X,1PE10.3,5X,I3,2X,5A4,2X,E10.3)
32726 CONTINUE
      WRITE (*,9472)
9472  FORMAT (/' ENTER INDEX NUMBER OF CONTAMINANT WHOSE UNSATURATED'/
     #          ' KD YOU WANT TO CHANGE OR ENTER 0 TO QUIT')
      READ (*,60,ERR=1110) INDX
      IF(.NOT.(INDX .NE. 0)) GO TO 32725
      IF ((INDX .LT. 0) .OR. (INDX .GT. 16)) GOTO 1110
9473  WRITE (*,9474) (CHMNAM(J,INDX),J=1,5),UKD(INDX)
9474  FORMAT (/,' EXISTING UNSATURATED KD FOR ',5A4,' IS ',1PE10.3,/
     #           ' ENTER NEW VALUE')
      READ (*,120,ERR=9473) RUKD
      UKD(INDX) = RUKD
      GOTO 1110
C----------------------
C   CHANGE SATURATED KDS
C----------------------
32725 CONTINUE
948   WRITE (*,9480)
9480  FORMAT (/' *****  ""SATURATED"" ZONE KD  *****   '//
     #          ' EXISTING SATURATED KD VALUES ARE:'/
     #          ' INDEX',2X,'CONTAMINANT',11X,'KD, L/KG')
      DO 32724 I=1,16
      WRITE (*,9481) I,(CHMNAM(J,I),J=1,5),SKD(I)
9481  FORMAT (1X,I5,2X,5A4,2X,1PE10.3)
32724 CONTINUE
      WRITE (*,9482)
9482  FORMAT (/' ENTER INDEX NUMBER OF CONTAMINANT WHOSE SATURATED'/
     #          ' KD YOU WANT TO CHANGE OR ENTER 0 TO QUIT')
      READ (*,60,ERR=948) INDX
      IF(.NOT.(INDX .NE. 0)) GO TO 32723
      IF ((INDX .LT. 0) .OR. (INDX .GT. 16)) GOTO 948
9483  WRITE (*,9484) (CHMNAM(J,INDX),J=1,5),SKD(INDX)
9484  FORMAT (/,' EXISTING SATURATED KD FOR ',5A4,' IS ',1PE10.3,/
     #           ' ENTER NEW VALUE')
      READ (*,120,ERR=9483) RSKD
      SKD(INDX) = RSKD
      GOTO 948
32723 GO TO 1
32727 IF((9).NE.(ISLECT)) GO TO 32722
C----------------------------
C  CONTAMINANT DEGRADATION DATA
C----------------------------
```

```
C
C-------------------------------
C   UNSATURATED DEGRADATION RATES
C-------------------------------
949   WRITE (*,9490)
9490  FORMAT (//' *****  ""UNSATURATED ZONE""  *****'/
     #          ' EXISTING UNSATURATED DEGRADATION CONSTANTS ARE:'//
     #          2X,'#',2X,'CONTAMINANT',10X,'LAMBDA, 1/YR'
     #          6X,'#',2X,'CONTAMINANT',10X,'LAMBDA, 1/YR'/)
      DO 32721 I=1,15,2
      II = I + 1
      WRITE (*,9471) I,(CHMNAM(J,I),J=1,5),ULAMBD(I),
     # II,(CHMNAM(J,II),J=1,5),ULAMBD(II)
32721 CONTINUE
      WRITE (*,9492)
9492  FORMAT (/' SELECT:'/
     # ' >0 INDEX NUMBER OF CONTAMINANT WHOSE UNSATURATED'/
     # '    DEGRADATION RATE YOU WANT TO CHANGE'/
     # '  0 PROCEED TO SATURATED DECAY CONSTANTS'/)
      READ (*,60,ERR=949) INDX
      IF (INDX .GT. 16) GOTO 949
      IF (INDX .LE. 0) GO TO 32720
C------------
C CHANGE VALUE
C------------
9493  WRITE (*,9494) (CHMNAM(J,INDX),J=1,5),ULAMBD(INDX)
9494  FORMAT (/,' EXISTING UNSATURATED LAMBDA FOR ',5A4,' IS ',
     #        1PE10.3,/' ENTER NEW VALUE')
      READ (*,120,ERR=9493) RULA
      ULAMBD(INDX) = RULA
      GOTO 949
C-----------------------------
C   SATURATED DEGRADATION RATES
C-----------------------------
32720 CONTINUE
950   WRITE (*,9500)
9500  FORMAT (//' *****  "SATURATED ZONE""  *****'/
     #          ' EXISTING SATURATED DEGRADATION CONSTANTS ARE:'//
     #          2X,'#',2X,'CONTAMINANT',10X,'LAMBDA, 1/YR'
     #          6X,'#',2X,'CONTAMINANT',10X,'LAMBDA, 1/YR'/)
      DO 32714 I=1,15,2
      II = I + 1
      WRITE (*,9471) I,(CHMNAM(J,I),J=1,5),SLAMBD(I),
     # II,(CHMNAM(J,II),J=1,5),SLAMBD(II)
32714 CONTINUE
      WRITE (*,9502)
9502  FORMAT (/' SELECT:'/
     # ' >0 INDEX NUMBER OF CONTAMINANT WHOSE SATURATED'/
     # '    DEGRADATION RATE YOU WANT TO CHANGE'/
     # '  0 PROCEED TO MAIN MENU'/)
      READ (*,60,ERR=950) INDX
      IF (INDX .GT. 16) GOTO 950
      IF (INDX .LE. 0) GO TO 1
C------------
C CHANGE VALUE
C------------
9503  WRITE (*,9504) (CHMNAM(J,INDX),J=1,5),SLAMBD(INDX)
9504  FORMAT (/,' EXISTING SATURATED LAMBDA FOR ',5A4,' IS ',
     #        1PE10.3,/' ENTER NEW VALUE')
      READ (*,120,ERR=9503) RSLA
      SLAMBD(INDX) = RSLA
      GOTO 950
32722 IF((10).NE.(ISLECT)) GO TO 32707
C--------------------------------
C  CHANGE BACKGROUND CONCENTRATIONS
C--------------------------------
945   WRITE (*,9451)
9451  FORMAT (/' EXISTING BACKGROUND CONCENTRATION DATA:'//
     #       1X,'INDEX',2X,'CONTAMINANT',10X,'CBACK, MG/L'/)
      DO 32706 I=1,16
      WRITE (*,9452) I,(CHMNAM(J,I),J=1,5),CBACK(I)
9452  FORMAT (1X,I5,2X,5A4,2X,1PE10.4)
32706 CONTINUE
      WRITE (*,9453)
9453  FORMAT (/' ENTER INDEX NUMBER OF CONTAMINANT WHOSE'/
     #          ' CONCENTRATION YOU WANT TO CHANGE OR ENTER 0 TO QUIT')
      READ (*,60,ERR=945) INDX
      IF (INDX .EQ. 0) GO TO 32705
      IF ((INDX .LT. 0) .OR. (INDX .GT. 16)) GOTO 945
9454  WRITE (*,9455) (CHMNAM(J,INDX),J=1,5),CBACK(INDX)
9455  FORMAT (/,' EXISTING BACKGROUND CONCENTRATION OF ',5A4,' IS ',
     #        1PE10.3,/' ENTER NEW VALUE')
      READ (*,120,ERR=9454) RCB
      CBACK(INDX) = RCB
      GOTO 945
C------------------------------
C CHANGE EFFECTS THRESHOLD VALUES
C------------------------------
32705 GO TO 1
32707 IF((11).NE.(ISLECT)) GO TO 610
600   WRITE(*,601)
601   FORMAT(//' CONTAMINANTS AND EFFECTS THRESHOLD VALUES'//
     #       4X'#  CONTAMINANT',14X,'VALUES'/)
      DO 32703 I=1,16
      WRITE(*,602) I,(CHMNAM(J,I),J=1,5),ADI(I)
32703 CONTINUE
```

```
602    FORMAT(I5,')',1X,5A4,1PE10.3)
       WRITE(*,603)
603    FORMAT(/' ENTER THE # OF THE CONTAMINANT YOU WISH TO CHANGE'/
     # ' ENTER <CR> TO RETURN TO MAIN MENU'/)
       READ(*,604,ERR-600) I
604    FORMAT(I5)
       IF (I.GT.16) GO TO 600
       IF(.NOT.(I.NE.0)) GO TO 32702
       WRITE (*,605) (CHMNAM(J,I),J-1,5)
605    FORMAT(/' ENTER NEW EFFECTS THRESHOLD VALUE FOR ',5A4/)
       READ (*,120,ERR-600,END-999) ADI(I)
       GO TO 600
32702 GO TO 1
C------------------------
C VAPOR PATHWAY PARAMETERS
C------------------------
C610  IF (12.NE.ISLECT) GO TO 640
610   IF (12.NE.ISLECT) GO TO 32753
      WRITE (*,612) VEL
612   FORMAT(/' *** VAPOR PATHWAY PARAMETERS ***'//
     + ' EXISTING VALUE OF AVERAGE SURFACE WIND VELOCITY IS',F6.1' M/S'/
     + ' ENTER NEW VALUE OR <CR> FOR NO CHANGE')
      READ (*,120) VELN
      IF (VELN.NE.0.) VEL - VELN
      WRITE (*,613) TEMP
613   FORMAT(/' EXISTING VALUE OF AVERAGE AIR TEMPERATURE IS',F6.1,
     + ' DEG C'/' ENTER NEW VALUE OR <CR> FOR NO CHANGE')
      READ (*,120) TEMPN
      IF (TEMPN.NE.0.) TEMP - TEMPN
      WRITE (*,614) PA
614   FORMAT(/' EXISTING VALUE OF AIR FILLED POROSITY OF THE',
     + ' COVER SOIL IS',F6.2/' ENTER NEW VALUE OR <CR> FOR NO CHANGE')
      READ (*,120) PAN
      IF (PAN.NE.0.) PA - PAN
      WRITE (*,616) PT
616   FORMAT(/' EXISTING VALUE OF TOTAL POROSITY OF THE COVER SOIL IS',
     + F6.2/' ENTER NEW VALUE OR <CR> FOR NO CHANGE')
      READ (*,120) PTN
      IF (PTN.NE.0.) PT - PTN
      WRITE (*,618) TCA
618   FORMAT(/' EXISTING VALUE OF COVER THICKNESS DURING ACTIVE PERIOD',
     + ' IS',F6.2' M'/' ENTER NEW VALUE OR <CR> FOR NO CHANGE')
      READ (*,120) TCAN
      IF (TCAN.NE.0.) TCA - TCAN
      WRITE (*,620) TCP
620   FORMAT(/' EXISTING VALUE OF POST CLOSURE COVER THICKNESS IS',
     + F6.2' M'/' ENTER NEW VALUE OR <CR> FOR NO CHANGE')
      READ (*,120) TCPN
      IF (TCPN.NE.0.) TCP = TCPN
      WRITE (*,621) XA
621   FORMAT(/' EXISTING VALUE OF ACTIVE CELL LENGTH IS',F6.1' METERS'/
     + ' ENTER NEW VALUE OR <CR> FOR NO CHANGE')
      READ (*,120) XAN
      IF (XAN.NE.0.) XA = XAN
622   WRITE (*,624) (I,(CHMNAM(J,I),J=1,4),H(I),
     + I+1,(CHMNAM(J,I+1),J=1,4),H(I+1),I=1,15,2)
624   FORMAT(/' HENRY''S LAW CONSTANTS FOR THE 16 CHEMICALS ARE:'//
     + '  INDX   CHEMICAL          HENRYS LAW    INDX   CHEMICAL        ',
     + 'HENRYS LAW'/'  ---- --------------- ---------',
     + '     ---- --------------- ---------'/
     + (I5,2X,4A4,1PE11.3,I7,2X,4A4,E11.3) )
      WRITE (*,626)
626   FORMAT(/' ENTER THE INDEX OF THE CHEMICAL YOU WANT TO CHANGE'/
     + ' OR <CR> TO PROCEED TO MOLECULAR WEIGHTS'/)
      READ (*,60,ERR=622,END=999) INDX
      IF (INDX.EQ.0) GO TO 632
628   WRITE (*,630) (CHMNAM(J,INDX),J=1,5)
630   FORMAT(' ENTER HENRY''S LAW CONSTANT FOR ',5A4)
      READ (*,120,ERR=628,END=999) H(INDX)
      GO TO 622
632   WRITE (*,634) (I,(CHMNAM(J,I),J=1,4),RMW(I),
     + I+1,(CHMNAM(J,I+1),J=1,4),RMW(I+1),I=1,15,2)
634   FORMAT(/' CURRENT MOLECULAR WEIGHTS FOR THE CHEMICALS ARE:'//
     + '  INDX   CHEMICAL           MOL WGHT     INDX   CHEMICAL     ',
     + '   MOL WGHT'/'  ---- --------------- ---------',
     + '     ---- --------------- ---------'/
     + (I5,2X,4A4,F9.2,I7,2X,4A4,F9.2) )

      WRITE (*,636)
636   FORMAT(/' ENTER THE INDEX OF THE CHEMICAL WHOSE MOL WGHT YOU ',
     + 'WISH TO CHANGE'/' OR ENTER <CR> TO RETURN TO MAIN MENU')
      READ (*,60,ERR=632,END=999) INDX
      IF (INDX.EQ.0) GO TO 1
      WRITE (*,638) (CHMNAM(J,INDX),J=1,5)
638   FORMAT(' ENTER MOLECULAR WEIGHT FOR ',5A4)
      READ (*,120,ERR=632,END=999) RMW(INDX)
      GO TO 632
C-----------------------------------------------------------
C BACK-CALCULATE ALLOWABLE INPUT (DRY WEIGHT) CONCENTRATIONS
C-----------------------------------------------------------
C640   IF((13).NE.ISLECT) GO TO 32704
C     WRITE (*,650) ITER
C650   FORMAT(/' CURRENT VALUE OF ITER IS',I5//
C    + ' SELECT VALUE:'/' (0) NO BACK-CALCULATION PERFORMED'/
C    + ' (1) BACK-CALCULATE ALLOWABLE INPUT CONCENTRATIONS')
C     READ (*,*) ITER
```

```
C     GO TO 1
C------------
C  INPUT ERROR
C------------
32704 WRITE (*,9462)
9462  FORMAT (/' ERROR -- UNALLOWABLE VALUE')
      GO TO 1
C
32753 GO TO 1
8000  CONTINUE
      CALL DATE(10,CHDATE)
      CALL TIME(10,CHTIME)
      WRITE (7,7001) CHDATE,CHTIME
7001  FORMAT (17X,'****************** SLUDGEMAN ******************'/
     #         17X,'*    DRAFT COMMENT VERSION 0.00, DEC., 1987   *'/
     #         17X,'*                                              *'/
     #         17X,'*           OUTPUT FILE SLUDGFIX.DES          *'/
     #         17X,'*       CREATED BY PROGRAM SLUDGFIX.EXE       *'/
     #         17X,'*          ON ',A10,' AT ',A10,'         *'/
     #         17X,'*                                              *'/
     #         17X,'*      FILE CONTAINS HARD COPY OF CORRECTED    *'/
     #         17X,'*                 SITE INPUT DATA              *'/
     #         17X,'*                                              *'/
     #         17X,'************************************************')
      WRITE (7,7002) CASE
      WRITE (8,8010) CASE
7002  FORMAT (//,1X,'CASE NAME: 'A64,//)
8010  FORMAT (1X,A64)
      WRITE (7,7003)
7003  FORMAT (1X,79('='),/,25X,'CONTAMINANT CONCENTRATION DATA',
     #     /,1X,79('='),//,1X,'CONTAMINANT',11X,'CL, MG/L',4X,'CS, MG/KG'
     #     2X,'EFFECTS LEVEL, MG/L'/1X,11('-'),11X,8('-'),4X,9('-'),2X,
     #     19('-'))
      DO 32701 I=1,16
      WRITE (7,7004) (CHMNAM(J,I),J=1,5),CL(I),CS(I),ADI(I)
      WRITE (8,802) CL(I),CS(I),ADI(I)
7004  FORMAT (1X,5A4,1P3E12.4)
802   FORMAT (1X,1P3E12.4)
32701 CONTINUE
C---------------------
C WRITE OUT SLUDGE DATA
C---------------------
      WRITE (7,703)
703   FORMAT (/1X,79('='),/,34X,'SLUDGE DATA'/,1X,79('='),/)
      WRITE (7,704) SLMC
      WRITE (8,804) SLMC
704   FORMAT (' SLUDGE MOISTURE CONTENT = ',F8.4,' KG/KG')
804   FORMAT (1X,F8.4)
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      WRITE (7,705) SLSC
      WRITE (8,804) SLSC
705   FORMAT (' SLUDGE STORAGE CAPACITY = ',F8.4,' KG/KG')
      WRITE (7,706) SLDN
      WRITE (8,806) SLDN
706   FORMAT (' SLUDGE DENSITY = ',F8.2,' KG/CU M')
806   FORMAT (1X,F8.2)
      WRITE (7,707)
C-------------------
C WRITE OUT SITE DATA
C-------------------
707   FORMAT (/,1X,79('='),/,35X,'SITE DATA',/,1X,79('='),/)
      WRITE (7,708) STRC
      WRITE (8,804) STRC
708   FORMAT (' NET RECHARGE = ',F8.4,' M/YR')
      WRITE (7,709) STDG
709   FORMAT (' DEPTH TO GROUNDWATER = ',F8.4,' M')
      WRITE (7,710) STDB
      WRITE (8,812) STDB
710   FORMAT (' DISTANCE TO LANDFILL BOUNDARY = ',F10.2,' M')
      WRITE (7,724) STWID
      WRITE (8,812) STWID
724   FORMAT (' SITE WIDTH = ',F8.2,' M')
      WRITE (7,725) STLEN
      WRITE (8,812) STLEN
725   FORMAT (' SITE LENGTH = ',F8.2,' M')
      WRITE (7,726) FLHT
      WRITE (8,812) FLHT
726   FORMAT (' FILL HEIGHT = ',F8.2,' M')
      WRITE (8,812) UDX
C------------------------------
C WRITE OUT UNSATURATED ZONE DATA
C------------------------------
      WRITE (7,711) UDX
711   FORMAT (/,1X,79('='),/,29X,'UNSATURATED ZONE DATA',/,1X,79('='),
     #       //' LONGITUDINAL DISPERSIVITY = ',1PE10.2//
     #       66X,'EFF BULK'/54X,'THETA SAT',3X,'DENSITY'
     #       /1X,'MATRIX',8X,'THICKNESS, M',4X,'K, M/YR',9X,'B',6X,
     #       'CU M/CU M',3X,'KG/CU M'/)
      WRITE (8,810) NLAYRS
810   FORMAT(1X,I5)
      DO 32700 I=1,NLAYRS
      WRITE (7,712) (SOILID(J,ITYPE(I)),J=1,4),THIK(I),
     #       UNHC(I),UB(I),UTHTA(I),UEFBD(I)
      WRITE (8,810) ITYPE(I)
      WRITE (8,811) THIK(I)
      WRITE (8,812) UNHC(I)
      WRITE (8,811) UB(I)
      WRITE (8,811) UTHTA(I)
      WRITE (8,811) UEFBD(I)
811   FORMAT (1X,F10.2)
812   FORMAT (1X,1P3E10.3)
712   FORMAT (1X,4A4,2X,F8.2,2X,1PE10.3,2X,0PF8.2,2(2X,F10.2))
32700 CONTINUE
      TTHIK = 0.
      SUMTHT = 0.
      SUMEBD = 0.
      DO 32699 I=1,NLAYRS
C--------------------------------------------------
C   CALCULATE TOTAL THICKNESS,
C      WEIGHTED AVERAGE POROSITY OF ALL LAYERS, AND
C      WEIGHTED AVERAGE BULK DENSITY OF ALL LAYERS.
C--------------------------------------------------
      TTHIK = TTHIK + THIK(I)
      SUMTHT = SUMTHT + THIK(I) * UTHTA(I)
      SUMEBD = SUMEBD + THIK(I) * UEFBD(I)
32699 CONTINUE
C--------------------------------------------------------------------
C   CALCULATE THE WEIGHTED AVERAGE POROSITY, BULK DENSITY, AND
C      DISTRIBUTION COEFFICIENT OF ALL UNSATURATED LAYERS BY DIVIDING
C      BY TOTAL THICKNESS.
C--------------------------------------------------------------------
      IF (TTHIK .LE. 0.) GO TO 32698
      AVTHTA = SUMTHT / TTHIK
      AVEFBD = SUMEBD / TTHIK
32698 WRITE (7,713) AVTHTA,AVEFBD
713   FORMAT (' WEIGHTED AVE',38X,F10.2,2X,F10.2)
      WRITE (7,7131)
7131  FORMAT (//42X,'UNSATURATED'/,26X,'UNSATURATED',5X,
     #       'DEGRADATION RATE',/,1X,'CONTAMINANT',14X,'KD, L/KG',8X,
     #       'CONSTANT, 1/YR',/)
      DO 32697 I=1,16
      WRITE (7,7132) (CHMNAM(J,I),J=1,5),UKD(I),ULAMBD(I)
7132  FORMAT (1X,5A4,2(5X,1PE10.3))
      WRITE (8,813) UKD(I),ULAMBD(I)
813   FORMAT (2(1X,1PE10.3))
32697 CONTINUE
C------------------------------
C WRITE OUT SATURATED ZONE DATA
C------------------------------
      WRITE (7,714)
      WRITE (8,810) IPHEH
714   FORMAT (/1X,79('='),/,30X,'SATURATED ZONE DATA',/,1X,79('='),/)
      WRITE (7,1714) IPHEH
      GWPH = 6.0
      IF (IPHEH.GT.3) GWPH = 7.0
      IADD = -3 * (IPHEH/4)
      GWEH = -200. + 350. * (IPHEH - 1 + IADD)
1714  FORMAT (' THE PH / EH CATEGORY IS =',I2)
      WRITE (7,715) GWPH
715   FORMAT (' GROUNDWATER PH = ',F7.1,' SU')
      WRITE (7,716) GWEH
716   FORMAT (' GROUNDWATER EH = ',F7.1,' MV')
      WRITE (8,816) ISATYP
816   FORMAT (1X,I2)
      WRITE (7,717) GWHC
      WRITE (8,812) GWHC
717   FORMAT (' AQUIFER HYDRAULIC CONDUCTIVITY = ',E10.4,' M/YR')
817   FORMAT (1X,E10.4)
      WRITE (7,718) GWEP
      WRITE (8,812) GWEP
718   FORMAT (' AQUIFER EFFECTIVE POROSITY = ',F8.2,' CU M/CU M')
      WRITE (7,719) GWGR
      WRITE (8,817) GWGR
719   FORMAT (' GROUNDWATER GRADIENT = ',E10.4,' M/M')
      WRITE (7,720) GWEBD
      WRITE (8,812) GWEBD
720   FORMAT (' AQUIFER EFFECTIVE BULK DENSITY = ',F8.2,' KG/CU M')
      WRITE (7,1724) AQDEP
      WRITE (8,812) AQDEP
1724  FORMAT (' AQUIFER THICKNESS = ',F8.2,' M')
      WRITE (7,1725) AQWID
      WRITE (8,812) AQWID
1725  FORMAT (' AQUIFER WIDTH = ',1PE12.2,' M')
      WRITE (7,721) DX,DY,DZ
      WRITE (8,812) DX,DY,DZ
721   FORMAT (
     #' LONGITUDINAL DISPERSIVITY = ',1PE10.3,' SQ M/YR'/
     #' TRANSVERSE   DISPERSIVITY = ',E10.3,' SQ M/YR'/
     #' VERTICAL     DISPERSIVITY = ',E10.3,' SQ M/YR')
C-------------------------------------------------------------------
C   SET THE MIXING DEPTH OF THE SATURATED LAYER TO THE DEPTH OF
C      PENETRATION OF THE RECHARGE.  THIS IS CALCULATED AS THE
C      RECHARGE DIVIDED BY SATURATED EFFECTIVE POROSITY.
C-------------------------------------------------------------------
      DEPTH = STRC / GWEP
      WRITE (7,727) DEPTH
727   FORMAT (' MIXING DEPTH OF AQUIFER = ',F8.2,' M'
     #       /' MIXING DEPTH = RECHARGE / SATURATED EFFECTIVE POROSITY')
      WRITE (8,812) DEPTH
      WRITE (7,7270)
7270  FORMAT (//41X,'SATURATED'/,26X,'SATURATED',6X,
     #       'DEGRADATION RATE',/,1X,'CONTAMINANT',14X,'KD, L/KG',7X,
     #       'CONSTANT, 1/YR'/)
```

```
      DO 32696 II=1,16
      WRITE (7,7271) (CHMNAM(J,II),J=1,5),SKD(II),SLAMBD(II)
7271  FORMAT (1X,5A4,2(5X,1PE10.3))
      WRITE (8,813) SKD(II),SLAMBD(II)
32696 CONTINUE
      WRITE (7,728)
728   FORMAT (//' BACKGROUND CONCENTRATIONS OF CONTAMINANTS',
     # ' IN GROUNDWATER'/
     #       ' CONTAMINANT',16X,'CONCENTRATION, MG/L')
      DO 32695 I=1,16
      WRITE (7,729) (CHMNAM(J,I),J=1,5),CBACK(I)
729   FORMAT (1X,5A4,5X,1PE10.2)
      WRITE (8,812) CBACK(I)
32695 CONTINUE
C----------------------
C WRITE VAPOR PARAMETERS
C----------------------
      WRITE (7,730) VEL,TEMP,PA,PT,TCA,TCP,XA,STLEN,STWID,
     + ((CHMNAM(J,I),J=1,4),H(I),RMW(I),I=1,16)
730   FORMAT(/' VAPOR PARAMETERS'/' ---------------'//
     + ' AVERAGE SURFACE WIND VEL ',F6.1' M/S'/
     + ' AVERAGE AIR TEMPERATURE  ',F6.1' DEG C'/
     + ' AIR FILLED COVER POROSITY',F6.2/
     + ' TOTAL COVER POROSITY     ',F6.2/
     + ' ACTIVE COVER THICKNESS   ',F6.2' M'/
     + ' POST CLOSURE COVER THICK.',F6.2' M'/
     + ' ACTIVE CELL LENGTH       ' ,F7.1' M'/
     + ' SITE LENGTH              ' ,F7.1' M'/
     + ' SITE WIDTH               ' ,F7.1' M'/
     + / '  CHEMICAL        HENRYS LAW  MOL WGHT'/
     +     ' --------------- --------- ---------'/
     + (1X,4A4,1PE11.3,0PF10.2) )
      WRITE (8,740) VEL,TEMP,PA,PT,TCA,TCP,XA,(H(I),RMW(I),I=1,16)
740   FORMAT(2(F10.1/),2F10.2/2F10.1/F10.1/(1PE12.3,0PF10.2) )
      WRITE (8,745) ITER
745   FORMAT(I5)
C
C WRITE SORPTION DATA
C
      OPEN (1,FILE='SLUDGN.SOR',STATUS='NEW')
      WRITE (1,751) NV
751   FORMAT(6I5)
      DO 780 I=1,6

     IF (NV(I).EQ.2) THEN
     WRITE (1,752) (CHEM(J,I),J= 1,18)
     WRITE (1,759) (CHEM(J,I),J=19,54)
     END IF
     IF (NV(I).EQ.3) THEN
     WRITE (1,753) (CHEM(J,I),J= 1,27)
     WRITE (1,759) (CHEM(J,I),J=28,54)
     END IF

     IF (NV(I).EQ.4) THEN
     WRITE (1,754) (CHEM(J,I),J= 1,36)
     WRITE (1,759) (CHEM(J,I),J=37,54)
     END IF

     IF (NV(I).EQ.5) THEN
     WRITE (1,755) (CHEM(J,I),J= 1,45)
     WRITE (1,759) (CHEM(J,I),J=46,54)
     END IF

     IF (NV(I).EQ.6) THEN
     WRITE (1,756) (CHEM(J,I),J=1,54)
     END IF

752   FORMAT(1P2E12.3)
753   FORMAT(1P3E12.3)
754   FORMAT(1P4E12.3)
755   FORMAT(1P5E12.3)
756   FORMAT(1P6E12.3)
759   FORMAT(9F3.0)
780   CONTINUE
      CLOSE (1)
999   CLOSE (7)
      CLOSE (2)
      END
```

Appendix CC - Program SLUGMAIN

```
$NOFLOATCALLS
$STORAGE:2
C######################################################################=
C   SLUGMAIN.FLX    -   MAR 1987
C
C   SLUGMAIN WITH 6 METALS FOR EPA SENSITIVITY ANALYSIS
C
C   MAIN SLUDGEMAN PROGRAM WHICH MAKES THE TIER 1 AND TIER 2
C      CALCULATIONS.
C   READS THE INPUT FILE CREATED BY SLUDGIN.FLX (SHORT FORM,
C      SLUDGE.TMP) OR THE INPUT FILE CHANGED BY SLUDGFIX.FLX
C      (SHORT FORM, SLUDGE.FIL).
C==####################################################################=
      INTERFACE TO SUBROUTINE TIME (N,STR)
      CHARACTER*10 STR [NEAR,REFERENCE]
      INTEGER*2 N [VALUE]
      END
      INTERFACE TO SUBROUTINE DATE (N,STR)
      CHARACTER*10 STR [NEAR,REFERENCE]
      INTEGER*2 N [VALUE]
      END
      DIMENSION CL(16),CS(16),HC(12),UNHC(5),UB(5),UTHTA(5),UEFBD(5),
     #    THIK(5),ADI(16),CMASS(16),PULSE(16),FOC(12),SAKD(16),SUMUKD(16),
     #    UCAP(16),SKD(16),UKD(16),TOT(5),CTOT(16),
     #    ULAMBD(16),SLAMBD(16),SSTHTA(5),CSAT(16),RF(16),
     #    TMAXCH(16),DTCH(16),NBGT1(16),NEDT1(16),NPRINT(16),
     #    ICHEM(16),CBACK(16)
      DIMENSION TTKN(24),FACT(24)
      REAL KOC(16),MASSO,MASSD,MASSL
      INTEGER ITYPE(5),IFLG1(16),IORGNC(16)
      CHARACTER*4 CHMNAM(5,16),RESULT(2),SOILID(4,12)
      CHARACTER*10 CHDATE,CHTIME
      CHARACTER*64 INFILE,CASE
      CHARACTER*60 CHNDES,ATDDES
C########=#############################################################====
C
C   DATA STATEMENTS
C
C########=#############################################################====
C-----------------------------
C   16 CONTAMINANTS SIMULATED:
C     6 METALS
C    10 ORGANICS
C-----------------------------
      DATA CHMNAM
     # /'ARSE','NIC ','    ','    ','    ',
     #    'CADM','IUM ','    ','    ','    ',
     #    'COPP','ER  ','    ','    ','    ',
     #    'LEAD','    ','    ','    ','    ',
     #    'MERC','URY ','    ','    ','    ',
     #    'NICK','EL  ','    ','    ','    ',
     #    'BENZ','ENE ','    ','    ','    ',
     #    'BENZ','O(A)','PYRE','NE  ','    ',
     #    'BIS(','2ETH','EX)P','THAL','ATE ',
     #    'CHLO','RDAN','E   ','    ','    ',
     #    'DDT/','DDE/','DDD ','    ','    ',
     #    'DIME','THYL','NITR','OSAM','INE ',
     #    'LIND','ANE ','    ','    ','    ',
     #    'PCBS','    ','    ','    ','    ',
     #    'TRIC','HLOR','OETH','YLEN','E   ',
     #    'TOXA','PHEN','E   ','    ','    '/
C---------------------------------------------------------------------
C FLAG AS TO WHETHER THE CONTAMINANT PASSES THE TIER 1 OR 2 ANALYSIS.
C---------------------------------------------------------------------
      DATA RESULT /'PASS','FAIL'/
C-----------------------------
C 12 MATERIAL TYPES SIMULATED.
C-----------------------------
      DATA SOILID
     # /'CLAY','    ','    ','    ','SILT','Y CL','AY  ','    ',
     #    'SILT','Y CL','AY L','OAM ','CLAY',' LOA','M   ','    ',
     #    'SAND','Y CL','AY L','OAM ','SAND','Y SI','LT L','OAM ',
     #    'SILT','Y LO','AM  ','    ','SAND','Y LO','AM  ','    ',
     #    'LOAM','Y SA','ND  ','    ','SAND','    ','    ','    ',
     #    'FRAC','. SA','NDST','ONE ','LIME','STON','E   ','    '/
C---------------------------------------------
C FLAG IDENTIFYING METALS (0) OR ORGANICS (1).
C---------------------------------------------
      DATA IORGNC /0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1/
C########################################################################
C
C   BEGIN MAIN PROGRAM
C
C########################################################################
C---------------------------------------------------
C OPEN 1 : FLAG.FLG  - INDICATE WHETHER CHAIN OR AT123D TO BE RUN
C      2 : SLUDGFIX.OUT - INPUT DATA FILE, OUTPUT FROM SLUDGFIX
C      7 : SLUDGMAN.DES  - DESCRIPTIVE OUTPUT FILE
C      8 : CHAIN.INP      - CHAIN INPUT FILE (FOR UNSATURATED TRANSPORT)
C      9 : AT123D.TMP     - AT123D INPUT FILE (SATURATED TRANSPORT)
C---------------------------------------------------
      OPEN (1,FILE='FLAG.FLG',STATUS='NEW')
      OPEN (2,FILE='SLUDGFIX.OUT',STATUS='OLD')
      OPEN (7,FILE='SLUGMAIN.DES',STATUS='NEW')
      OPEN (8,FILE='CHAIN.INP',STATUS='NEW',FORM='FORMATTED')
      OPEN (9,FILE='AT123D.TMP',STATUS='NEW',FORM='FORMATTED')
```

```
C--------------------------------------------
C NOTIFY THE USER THAT HE IS RUNNING SLUDGMAN
C--------------------------------------------
      WRITE (*,5)
5     FORMAT (//'             PROGRAM:  SLUGMAIN'/
     #    /'    THIS PROGRAM PERFORMS THE TIER 1 AND TIER 2 PRELIMINARY'
     #    /' ANALYSES TO DETERMINE WHICH CHEMICALS MAY REACH THE WATER'
     #    /' TABLE AT CONCENTRATIONS ABOVE EFFECTS THRESHOLD, THEREBY'
     #    /' NECESSITATING FURTHER, MORE DETAILED ANALYSES USING THE'
     #    /' "CHAIN" AND "AT123D" PROGRAMS.'///,' SEE THE SLUGMAIN.DES'
     #     ' FILE FOR COMPLETE RESULTS OF THIS PROGRAM.')
C
C  PAUSE SO OPERATOR CAN READ THE SCREEN.
C
      WRITE (*,10)
10    FORMAT (//' PRESS <CR> TO CONTINUE'//)
      READ (*,20) IPR
20    FORMAT (I2)
C-------------------------------------------------------------------
C QUERY USER ABOUT RUNNING CHAIN & AT123D EVEN IF TIERS 1 & 2 PASSED
C-------------------------------------------------------------------
      WRITE (*,30)
30    FORMAT(5X'DO YOU WISH TO CALCULATE GROUNDWATER CONCENTRATIONS'/
     + ' FOR CHEMICALS PASSING THE TIER 1 AND TIER 2 ANALYSES?'/
     + ' IF YOU DO, GROUNDWATER CONCENTRATIONS WILL BE CALCULATED FOR'/
     + ' ALL CHEMICALS IRREGARDLESS OF WHETHER THEY PASS OR FAIL THE'/
     + ' TIERS 1 AND 2 ANALYSES.'/
     + '    1 - YES,  CALCULATE CONCENTRATIONS FOR ALL CHEMICALS'/
     + ' <CR> - NO,   CALCULATE CONCENTRATIONS FOR ONLY THOSE FAILING'/
     + '              TIERS 1 AND 2.'/)
      READ (*,20) IAT
      NFAILT - 0
      IF (IAT.NE.0) NFAILT - 16
C######################################################################
C
C
C   READ THE INPUT DATA FILE (SLUDGE.FIL) CREATED BY SLUDGIN.FLX OR
C      SLUDGFIX.FLX.
C
C
C######################################################################
C--------------------
C READ IN NAME OF CASE
C--------------------
      READ (2,'(A)') CASE
C----------------------------------
C READ IN CONTAMINANT CONCENTRATIONS
C----------------------------------
```

```
      DO 32758 I=1,16
      READ (2,*) CL(I),CS(I),ADI(I)
32758 CONTINUE
C-------------------
C READ IN SLUDGE DATA
C-------------------
      READ (2,*) SLMC
      READ (2,*) SLSC
      READ (2,*) SLDN
C-----------------
C READ IN SITE DATA
C-----------------
      READ (2,*) STRC
      READ (2,*) STDB
      READ (2,*) STWID
      READ (2,*) STLEN
      READ (2,*) FLHT
      READ (2,*) UDX
C----------------------------
C READ IN UNSATURATED ZONE DATA
C----------------------------
      TTHIK  = 0.
      STHETA = 0.
      SEFBD  = 0.
      DO 32757 K=1,16
      SUMUKD(K) = 0.
32757 CONTINUE
      READ (2,*) NLAYER
      DO 32756 I=1,NLAYER
      READ (2,*) ITYPE(I)
      READ (2,*) THIK(I)
      READ (2,*) UNHC(I)
      READ (2,*) UB(I)
      READ (2,*) UTHTA(I)
      READ (2,*) UEFBD(I)
      TTHIK = TTHIK + THIK(I)
      STHETA = STHETA + THIK(I) * UTHTA(I)
      SEFBD = SEFBD + THIK(I) * UEFBD(I)
32756 CONTINUE
      DO 32755 L=1,16
      READ (2,*) UKD(L),ULAMBD(L)
32755 CONTINUE
      IF(.NOT.(TTHIK .GT. 0.)) GO TO 32754
      AVTHTA = STHETA / TTHIK
      AVEFBD = SEFBD / TTHIK
C--------------------------
C READ IN SATURATED ZONE DATA
C--------------------------
```

```
32754 READ (2,*) IPHEH
      READ (2,*) ISATYP
      READ (2,*) GWHC
      READ (2,*) GWEP
      READ (2,*) GWGR
      READ (2,*) GWEBD
      READ (2,*) AQDEP
      READ (2,*) AQWID
      READ (2,*) DX,DY,DZ
      READ (2,*) DEPTH
      READ (2,*) (SKD(I),SLAMBD(I),I=1,16)
      READ (2,*) (CBACK(I),I=1,16)
C#######################################################################
C
C  CALCULATE GROUNDWATER VELOCITY.
C
C#######################################################################
C CONVERT THE EFFECTIVE BULK DENSITY TO UNITS OF G/CU CM.
C---------------------------------------------------------
      GWEBD = GWEBD / 1000.
C-------------------------------------------------------------------
C CALCULATE THE GROUND WATER VELOCITY AS THE HYDRAULIC CONDUCTIVITY
C    TIMES THE GW GRADIENT DIVIDED BY THE POROSITY.
C-------------------------------------------------------------------
      AQVEL = GWHC * GWGR / GWEP
C#######################################################################
C
C
C PERFORM TIER I CHECK OF LEACHATE CONCENTRATION AGAINST EFFECTS
C   THRESHOLD VALUES OR ADI.
C
C
C  WRITE THE RESULTS OUT TO THE PRIMARY OUTPUT DATA FILE.
C#######################################################################
      CALL DATE(10,CHDATE)
      CALL TIME(10,CHTIME)
      WRITE (7,7001) CHDATE,CHTIME
7001  FORMAT (17X,'***************** SLUDGEMAN *******************'/
     #         17X,'*    DRAFT COMMENT VERSION 0.00, DEC., 1987   *'/
     #         17X,'*                                             *'/
     #         17X,'*          OUTPUT FILE SLUGMAIN.DES           *'/
     #         17X,'*      CREATED BY PROGRAM SLUGMAIN.EXE        *'/
     #         17X,'*          ON ',A10,' AT ',A10,'       *'/
     #         17X,'*                                             *'/
     #         17X,'*       FILE CONTAINS HARD COPY OF THE        *'/
     #         17X,'*               SLUGMAIN RESULTS              *'/
     #         17X,'***********************************************')
      WRITE (7,7261)
```

```
7261  FORMAT (//,1X,79('='),/,27X,' RESULTS OF TIER 1 ANALYSIS',/,
     #    1X,79('='),//,1X,'CONTAMINANT',11X,'CL, MG/L',4X,'ADI, MG/L',
     #    3X,'STATUS')
C      WRITE (*,200)
C200   FORMAT (///' BEGINNING TIER 1 ANALYSIS')
C
      IUNSAT = 0
      ISAT = 0
      NFAIL = 0
      DO 32753 I=1,16
      IFLG1(I) = 0
      IF (CS(I).LE.0.) CL(I) = 0.
      IF(.NOT.(CL(I).GT.ADI(I))) GO TO 32752
C      IF (NFAIL.EQ.0) WRITE(*,2001)
C2001  FORMAT(/' LEACHATE CONCENTRATIONS AT THE BOTTOM OF THE'
C     # ,' LANDFILL'/' EXCEED EFFECTS THRESHOLD VALUES FOR THE'
C     # ,' FOLLOWING CHEMICALS:'/)
C      WRITE (*,201) (CHMNAM(J,I),J=1,5)
C201   FORMAT (5X,5A4)
      IFLG1(I) = 1
      NFAIL = NFAIL + 1
      ICHEM(NFAIL) = I
32752 WRITE (7,727) (CHMNAM(J,I),J=1,5),CL(I),ADI(I),
     #    RESULT(IFLG1(I) + 1)
727   FORMAT (1X,5A4,2X,E10.4,2X,E10.4,2X,A4)
32753 CONTINUE
C
      IF(.NOT.(NFAIL .EQ. 0)) GO TO 32751
C      WRITE (*,202)
C202   FORMAT (/' NO CHEMICALS FAILED TIER 1 CHECK')
      WRITE (7,728)
728   FORMAT (//' NO CONTAMINANTS FAILED TIER 1'/
     #    ' PROGRAM ENDED')
      IF (IAT.EQ.0) GO TO 999
C
32751 IF(.NOT.(NFAIL.GT.0)) GO TO 32750
C      WRITE (*,10)
C      READ (*,20) IPR
C      WRITE (*,203) NFAIL
C203   FORMAT (/1X,I2,' CHEMICALS PASSED TO TIER 2'/)
      WRITE (7,729) NFAIL
729   FORMAT (//' TOTAL OF ',I2,' CHEMICALS FAILED TIER 1')
      ITATD = NFAIL
C      DO 32749 K=1,NFAIL
C      I = ICHEM(K)
C      WRITE (*,808) K,(CHMNAM(J,I),J=1,5),CL(I),ADI(I)
C808   FORMAT(1X,I2,'. ',5A4/10X'TIER 1 CONC =',1PE10.3,/
C     # ' EFFECTS THRES. VALUE =',E10.3/)
```

```
C32749 CONTINUE
C
C  PAUSE SO OPERATOR CAN READ THE SCREEN.
C
C      WRITE (*,10)
C      READ (*,20) IPR
C#########################################################################
C
C
C PERFORM TIER II CHECK OF LEACHATE CONCENTRATION AGAINST EFFECTS
C   THRESHOLD VALUES OR ADI FOR THOSE CONTAMINANTS NOT PASSING TIER I.
C
C
C#########################################################################
32750 CONTINUE
C32750 WRITE (*,204)
C204   FORMAT (///' STARTING PRELIMINARY TIER 2 ANALYSIS')
      WRITE (7,730)
730   FORMAT (//,1X,79('='),/,17X,' RESULTS OF THE PRELIMINARY TIER 2'
     #    ' ANALYSIS',/,1X,79('='),//)
C---------------------------------------
C CALCULATE MASS OF SLUDGE PER SQUARE METER
C---------------------------------------
      SLMASS = FLHT * SLDN
      WRITE (7,731) SLMASS
731   FORMAT (' TOTAL MASS OF SLUDGE = ',F10.2,' KG/ SQ M')
      SOLMAS = SLMASS * (1. - SLMC)
      WRITE (7,7311) SOLMAS
7311  FORMAT (' TOTAL MASS OF SLUDGE SOLIDS = ',F10.2,' KG/ SQ M')
C-------------------------------
C CALCULATE MASS OF EACH CONTAMINANT
C-------------------------------
      NFAILT = MAX (NFAIL,NFAILT)
      WRITE (7,732)
732   FORMAT (/' CONTAMINANT',8X,'MASS G/ SQ M')
      DO 32748 K=1,NFAILT
      I = K
      IF (IAT.EQ.0) I = ICHEM(K)
      CMASS(I) = CS(I) * SLMASS * (1. - SLMC) / 1000.
      WRITE (7,733) (CHMNAM(J,I),J=1,5),CMASS(I)
733   FORMAT (1X,5A4,F10.4)
32748 CONTINUE
C---------------------------------------------
C CALCULATE CHANGE IN WATER VOLUME DUE TO DRAINAGE
C---------------------------------------------
      WTSOLD = (1. - SLMC) * FLHT * SLDN
      V1H2O = SLMC * (WTSOLD / (1. - SLMC)) / 1000.
      V2H2O = SLSC * (WTSOLD / (1. - SLSC)) / 1000.
      H1 = V1H2O
      H2 = V2H2O
C-----------------------------------
C CALCULATE INITIAL SLUDGE WATER HEIGHT
C-----------------------------------
      WRITE (7,734) H1
734   FORMAT (/' INITIAL SLUDGE WATER HEIGHT PER CUBIC METER = ',
     #    F10.4,' M/CU M')
C------------------------------------------
C CALCULATE SLUDGE WATER HEIGHT AFTER DRAINAGE
C------------------------------------------
      WRITE (7,735) H2
735   FORMAT (' SLUDGE WATER HEIGHT PER CUBIC METER AFTER DRAINAGE = '
     #    ,F10.4,' M/CU M')
C------------------------------------------
C CALCULATE VOLUME OF WATER DRAINED FROM SLUDGE
C------------------------------------------
      DRAIN = 0.
      IF (H1.GT.H2) DRAIN = H1 - H2
      WRITE (7,736) DRAIN
736   FORMAT (' VOLUME OF WATER DRAINED = ',F10.4,' CU M/SQ M')
C------------------------------------------------------
C CALCULATE MASS OF CONTAMINANT LOST DURING SLUDGE DRAINAGE
C AND THE PULSE TIME FOR THE DESIRED CONTAMINANTS
C ALLOW LINDANE TO DEGRADE ONLY AFTER EXITING THE LANDFILL
C------------------------------------------------------
      WRITE (7,7361)
7361  FORMAT (//23X,'ORIGINAL',6X,'DRAINED',7X,'LEACHABLE'10X'PULSE'
     #    /1X,'CONTAMINANT',9X,3(2X,'MASS, G/SQ M')7X'TIME')
      DO 32747 K=1,NFAILT
      I = K
      IF (IAT.EQ.0) I = ICHEM(K)
737   MASSD = CL(I) * DRAIN
      MASSO = CMASS(I) - MASSD
C--------------------------------------------------------
C WARN USER IF DRAINED CONTAMINANT MASS EXCEEDS LEACHABLE MASS
C--------------------------------------------------------
      IF(.NOT.(MASSO .LT. 0.)) GO TO 32741
      WRITE (*,739) (CHMNAM(J,I),J=1,5),(CHMNAM(J,I),J=1,5)
      WRITE (7,739) (CHMNAM(J,I),J=1,5),(CHMNAM(J,I),J=1,5)
739   FORMAT(/' *** DRAINED CONTAMINANT MASS EXCEEDS LEACHABLE ***'/
     + ' FOR',5X,5A4//
     + ' YOUR LEACHATE CONCENTRATION IS TOO LARGE'/
     + ' IN RELATION TO YOUR DRY WEIGHT CONCENTRATION.'/
     + ' YOU NEED TO ADJUST ONE OR THE OTHER.'//
     + ' ENTER NEW LEACHATE & DRY WEIGHT CONCENTRATION FOR ',5A4)
      READ (*,*)  CL(I),CS(I)
      CMASS(I) = CS(I) * SLMASS * (1. - SLMC) / 1000.
      GO TO 737
32741 CONTINUE

      MASSL = CL(I) * STRC
      PULSE(I) = 0.
      IF(.NOT.(CL(I).GT.0)) GO TO 32746
      IF(.NOT.(I.EQ.13)) GO TO 32744
      PULSE(I) = MASSO / MASSL
      GO TO 32745
32744 IF(.NOT.(ULAMBD(I) .EQ. 0)) GO TO 32742
      PULSE(I) = MASSO / MASSL
      GO TO 32743
32742 PULSE(I) = LOG( (MASSL / (MASSL + ULAMBD(I) * MASSO))) /
     #    (-1. * ULAMBD(I))
32743 CONTINUE
32745 CONTINUE
32746 WRITE (7,738) (CHMNAM(J,I),J=1,5),CMASS(I),MASSD,MASSO,PULSE(I)
738   FORMAT (1X,5A4,4(1PE12.3,2X))

32747 CONTINUE
C--------------------------------
C CALCULATE UNSATURATED TRAVEL TIME
C--------------------------------
      IF(.NOT.(TTHIK .GT. 0.)) GO TO 32739
      WRITE (7,742)
742   FORMAT (/' MATRIX',12X,'S.S. THETA',2X,'TOT, YR')
      TTOT = 0.
      DO 32738 I=1,NLAYER
      EXPO = 1. / (2. * UB(I) + 3.)
      SSTHTA(I) = UTHTA(I) * ((STRC / UNHC(I)) ** EXPO)
      TOT(I) = THIK(I) * SSTHTA(I) / STRC
      WRITE (7,743) (SOILID(J,ITYPE(I)),J=1,4),SSTHTA(I),TOT(I)
743   FORMAT (1X,4A4,2X,E10.4,2X,E10.4)
      TTOT = TTOT + TOT(I)
32738 CONTINUE
      WRITE (7,744) TTOT
744   FORMAT (1X,'UNSATURATED ZONE WATER TRAVEL TIME (YR) =',1PE12.4)
      VELAVE = TTHIK / TTOT
      UDX = VELAVE * UDX
      WRITE (7,7441) VELAVE
7441  FORMAT (/1X,'AVERAGE UNSATURATED WATER VELOCITY = ',1PE12.4,
     + ' M/YR')
      AMOIST = STRC / VELAVE
      WRITE (7,7442) AMOIST
7442  FORMAT (1X,'AVERAGE UNSATURATED MOISTURE CONTENT = ',F10.4,
     #    ' CU M/CU M')
C-----------------------------------------------
C CALCULATE UNSATURATED ZONE CONTAMINANT TRAVEL TIME
```

```
C---------------------------------------------------
      WRITE (7,745)
745   FORMAT (//1X,'CONTAMINANT',11X,'TRAVEL TIME, YR  RETARD FACT.')
      DO 32737 K=1,NFAILT
      I = K
      IF (IAT.EQ.0) I = ICHEM(K)
C--------------------------
C CALCULATE RETARDATION FACTOR
C--------------------------
      RF(I) = 1. + (AVEFBD * UKD(I) * 0.001 / AVTHTA)
C------------------------------------------------------------
C CALCULATE RETARDED TRAVEL TIME THROUGH THE UNSATURATED ZONE
C------------------------------------------------------------
      CTOT(I) = TTOT * RF(I)
C--------------------------------------------------
C ESTIMATE THE TIME STEPS TO USE IN THE CHAIN MODEL
C--------------------------------------------------
      TMAXCH(I) = 4. * CTOT(I) + PULSE(I)
      DTCH(I) = TMAXCH(I) / 40.
C
      WRITE (7,746) (CHMNAM(J,I),J=1,5),CTOT(I),RF(I)
746   FORMAT (1X,5A4,1P2E14.4)
32737 CONTINUE
      WRITE (7,7460) CASE
7460  FORMAT (////,1X,A64)
      WRITE (7,7461) STRC,AMOIST,VELAVE,TTHIK
7461  FORMAT (//' SUMMARY OF INPUT DATA FOR UNSATURATED TRANSPORT'
     # ' CALCULATIONS'//
     #     ' ANNUAL RECHARGE = ',F10.4,' M/YR'/
     #     ' STEADY STATE MOISTURE CONTENT = ',F10.4,' CU M/CU M'/
     #     ' STEADY STATE PORE WATER VELOCITY = ',F10.4,' M/YR'/
     #     ' DEPTH TO WATER TABLE = ',F10.4,' M'//
     #     ' CONTAMINANT',11X,'CONC, G/CU M',6X,'KD, L/KG',5X,
     #     'PULSE, YR',3X,'LAMDBA, 1/YR')
      DO 32736 K=1,NFAILT
      I = K
      IF (IAT.EQ.0) I = ICHEM(K)
      WRITE (7,7462) (CHMNAM(J,I),J=1,5),CL(I),UKD(I),PULSE(I),
     #    ULAMBD(I)
7462  FORMAT (1X,5A4,1P4(2X,E12.4))
32736 CONTINUE
C-------------------------------------------------------------
C CALCULATE CONCENTRATION REDUCTION DUE TO DECAY IN UNSATURATED
C ZONE (ASSUMING NO DISPERSION).  COMPARE DEGRADED CONCENTRATION
C WITH ADI AS TIER 2 CHECK.
C-------------------------------------------------------------
      WRITE (7,748)
748   FORMAT (//1X,'CONTAMINANT',11X,'CONC, G/CU M',3X,'ADI, G/CU M',
     #    2X,'STATUS')
C-----------------------------------------------------------------------
C ITCHN = TOTAL NUMBER OF CONTAMINANTS THAT NEED TO BE SIMULATED WITH
C      THE CHAIN MODEL BECAUSE THEY EXCEED THE EFFECTS THRESHOLD VALUE.
C-----------------------------------------------------------------------
      ITCHN = 0
      DO 32735 K=1,NFAILT
      I = K
      IF (IAT.EQ.0) I = ICHEM(K)
      IFLAG2 = 0
      CSAT(I) = CL(I) * EXP(-1. * ULAMBD(I) * CTOT(I))
      IF(.NOT.(CSAT(I) .GT. ADI(I))) GO TO 32734
      IFLAG2 = 1
      ITCHN = ITCHN + 1
      ICHEM(ITCHN) = I
32734 WRITE (7,749)(CHMNAM(J,I),J=1,5),CSAT(I),ADI(I),RESULT(IFLAG2+1)
749   FORMAT (1X,5A4,2(2X,E12.4),2X,A4)
32735 CONTINUE
C-------------------------------------------------
C ITCHN < 0 SKIP WRITING INPUT FILES FOR CHAIN & AT123D
C-------------------------------------------------
      IF (ITCHN.EQ.0 .AND. IAT.EQ.0) GO TO 999
C###################################################################====
C
C   WRITE THE INPUT FILE FOR THE CHAIN MODEL FOR THE CONTAMINANTS WHOSE
C       LEACHATE CONCENTRATION EXCEEDS THE EFFECTS THRESHOLD VALUE.
C
C###################################################################====
C
C-----------------------------------------------
C FIRST, LIST THE CONTAMINANTS THAT FAIL TIER 1 AND 2
C-----------------------------------------------
C      IF(.NOT.(ITCHN.GT.0)) GO TO 32732
C      WRITE (*,801) ITCHN
C801   FORMAT (/I4,' CONTAMINANTS FAILED THE PRELIMINARY TIER 2'
C     #  ,' ANALYSIS.'/' THESE CONTAMINANTS ARE:'/)
C      DO 32731 K=1,ITCHN
C      I = ICHEM(K)
C      WRITE (*,802) I,(CHMNAM(J,I),J=1,5),CSAT(I),ADI(I)
C802   FORMAT(1X,'(',I2,') ',5A4/10X'TIER 2 CONC =',1PE10.3,/
C     # ' EFFECTS THRES. VALUE =',E10.3/)
C32731 CONTINUE
C      GO TO 32733
C32732 WRITE(*,*)'NO CONTAMINANTS FAILED PRELIMINARY TIER 2'
C----------------------------------------------
C SET ITCHN TO NUMBER OF CHEMICALS RUN THROUGH CHAIN
C----------------------------------------------
32733 IF (IAT.NE.0) ITCHN = 16
```

```
C---------------------------------------------------
C WRITE HEADING TO INPUT FILE IF CHAIN IS TO BE RUN
C---------------------------------------------------
      IF(.NOT.(ITCHN.GT.0)) GO TO 32730
      CHNDES = ' CHAIN MODEL INPUT FILE'
C-------------------------------------------------------------------
C WRITE THE CHAIN MODEL INPUT FILE.
C
C SET CONSTANT VALUES FOR CERTAIN CHAIN MODEL INPUT PARAMETERS.
C-------------------------------------------------------------------
      NS = 1
      NR = 1
      NB = 0
      KSURF = 0
      KDB = 0
      KPR = 1
      WC = 0.0
      D1 = 1.1
      D2 = 1.01
      D3 = 1.001
      ZERO = 0.0
C
      DO 32729 I=1,16
      IF(.NOT.(CSAT(I) .GT. 0.)) GO TO 32728
      IF(.NOT.(CSAT(I) .GT. ADI(I) .OR. IAT.NE.0)) GO TO 32727
      IUNSAT = 1
      WRITE (8,805) (CHMNAM(J,I),J=1,5),CHNDES
805   FORMAT (1X,5A4,4X,A60)
      WRITE (8,806) NS,NR,NB,KSURF,KDB,KPR,VELAVE,UDX,WC,PULSE(I)
806   FORMAT (6I5,1P4E10.3)
      WRITE (8,807) RF(I),D1,D2,D3,ULAMBD(I),D1,D2,D3
807   FORMAT (1P8E10.3)
      WRITE (8,807) 0.,0.,0.,0.,0.,0.,0.,0.
      WRITE (8,807) TTHIK,ZERO,TTHIK,0.,DTCH(I),TMAXCH(I)
      WRITE (8,807) CL(I),0.,0.,0.,0.,0.,0.,0.,0.,0.
32727 CONTINUE
32728 CONTINUE
32729 CONTINUE
32730 GO TO 32740
32739 ISAT = 1
      WRITE (7,747)
747   FORMAT (/' ZERO DEPTH OF UNSATURATED ZONE'/
     #     ' UNSATURATED CAPACITY AND TRAVEL TIMES NOT CALCULATED')
C========================================================================
C
C   IF AN UNSATURATED ZONE IS NOT PRESENT, WRITE THE INPUT FILE FOR THE
C      AT123D SATURATED ZONE TRANSPORT MODEL FOR THE CONTAMINANTS WHOSE
C      LEACHATE CONCENTRATION EXCEEDS THE EFFECTS THRESHOLD VALUE.
```

```
C
C#######################################################################
C   FIRST, LIST THE CONTAMINANTS THAT FAILED TIER 1, AND SET THE
C   CSAT TO THE APPROPRIATE CL SO WE WRITE THE AT123D.TMP FILE
C#######################################################################
C
C      WRITE (*,901) ITATD
C901   FORMAT (/I4,' CONTAMINANTS FAILED THE TIER 1 ANALYSIS.'
C     #  /' SINCE THERE IS NO UNSATURATED ZONE PRESENT, THE AT123D'
C     #  /' SATURATED TRANSPORT MODEL SHOULD BE RUN FOR THESE'
C     #  /' CONTAMINANTS')
      DO 32726 I=1,16
C      IF (CL(I).GE.ADI(I)) WRITE (*,8021) (CHMNAM(J,I),J=1,5)
C8021  FORMAT (1X,5A4)
      CSAT(I) = CL(I)
32726 CONTINUE
32740 ATDDES = ' AT123D INPUT FILE'
C-----------------------------------------------------------------
C   WRITE THE AT123D MODEL INPUT FILE.
C
C   SET CONSTANT VALUES FOR CERTAIN AT123D MODEL INPUT PARAMETERS.
C-----------------------------------------------------------------
      NX =1
      NY =1
      NZ =1
      NROOT = 1000
      INSTAN = 1
      NSOUS = 0
      INTER = 1
      ICASE = 2
      IWID = 1
      IDEP = 1
      IBUG = 0
      AKE = 0.0
      AMTAU = 0.0
      RHOW = 1000.
      ACCU = 0.001
      YDIM = 0.5 * STWID
      ZDIM = 0.0
C-------------------------------------------------------------------
C CALCULATE THE LENGTH OF TRAVEL IN THE AQUIFER AS THE LENGTH OF THE
C    SOURCE (STLEN) PLUS THE DISTANCE TO THE SITE BOUNDARY (STDB).
C-------------------------------------------------------------------
      STLENP = STLEN + STDB
C
      DO 32725 I=1,16
      IF(.NOT.(CSAT(I) .GT. 0.)) GO TO 32724
      IF(.NOT.(CSAT(I) .GT. ADI(I) .OR. IAT.NE.0)) GO TO 32723
      ISAT = 1
      WRITE (9,805) (CHMNAM(J,I),J=1,5),ATDDES
      WRITE (9,903) NX,NY,NZ,NROOT,NBGT1(I),NEDT1(I),NPRINT(I),
     #     INSTAN,NSOUS,INTER,ICASE,IWID,IDEP,IBUG,I,IPHEH
 903  FORMAT (16I5)
      WRITE (9,904) AQDEP,AQWID,0.,STLEN,0.,STWID,0.,DEPTH
 904  FORMAT (8F10.2)
      WRITE (9,905) GWEP,GWHC,GWGR,DX,DY,DZ,SKD(I),AKE
 905  FORMAT (1P8E10.3)
      Q = CSAT(I)
      WRITE (9,905) AMTAU,SLAMBD(I),GWEBD,RHOW,ACCU,DTAT,
     #     PULSE(I),Q
      WRITE (9,907) STLENP,STRC,CBACK(I),CTOT(I)
      WRITE (9,904) YDIM
      WRITE (9,904) ZDIM
 907  FORMAT(2F10.2,1P2E10.2)
32723 CONTINUE
32724 CONTINUE
32725 CONTINUE
C#####################################################################
C
C   WRITE OUT THE SATURATED ZONE DATA TO THE PRIMARY INPUT FILE AT THIS
C       TIME WHETHER OR NOT AN UNSATURATED ZONE EXISTS.
C
C#####################################################################
      AQVEL = GWHC * GWGR / GWEP
      WRITE (7,7490) AQVEL,DX,GWEP
 7490 FORMAT (////,1X,79('='),/,30X,'SATURATED ZONE DATA',/,1X,79('=')
     #     ,//,' AQUIFER VELOCITY = ',E10.4,'M/YR',/
     #     ' LONGITUDINAL DISPERSION COEFFICIENT = ',E10.4,' SQ M/YR',/
     #     ' AQUIFER EFFECTIVE POROSITY = ',E10.4,' CU M/CU M')
      WRITE (7,7491)
 7491 FORMAT (//' CONTAMINANT',13X,'PULSE, YRS',4X,'RETAR FACT',2X,
     #     'LAMBDA, 1/YR',2X,'CONC, G/CU M')
      DO 32722 I=1,16
      SATRD = 1. + GWEBD * SKD(I) / GWEP
      IF(.NOT.(TTHIK .EQ. 0)) GO TO 32720
      CONCE = CL(I)
      GO TO 32721
32720 CONCE = CSAT(I)
32721 WRITE (7,751)(CHMNAM(J,I),J=1,5),PULSE(I),SATRD,SLAMBD(I),CONCE
751   FORMAT (1X,5A4,4(2X,E12.4))
32722 CONTINUE
C---------------------------
C WRITE "FLAG" INDICATOR FILE
C---------------------------
999   WRITE (1,*) IUNSAT,ISAT
      CLOSE (1)
      ISAT - 1
      WRITE (9,805) (CHMNAM(J,I),J-1,5),ATDDES
      WRITE (9,903) NX,NY,NZ,NROOT,NBGT1(I),NEDT1(I),NPRINT(I),
     #    INSTAN,NSOUS,INTER,ICASE,IWID,IDEP,IBUG,I,IPHEH
903   FORMAT (16I5)
      WRITE (9,904) AQDEP,AQWID,0.,STLEN,0.,STWID,0.,DEPTH
904   FORMAT (8F10.2)
      WRITE (9,905) GWEP,GWHC,GWGR,DX,DY,DZ,SKD(I),AKE
905   FORMAT (1P8E10.3)
      Q - CSAT(I)
      WRITE (9,905) AMTAU,SLAMBD(I),GWEBD,RHOW,ACCU,DTAT,
     #    PULSE(I),Q
      WRITE (9,907) STLENP,STRC,CBACK(I),CTOT(I)
      WRITE (9,904) YDIM
      WRITE (9,904) ZDIM
907   FORMAT(2F10.2,1P2E10.2)
32723 CONTINUE
32724 CONTINUE
32725 CONTINUE
C######################################################################
C
C   WRITE OUT THE SATURATED ZONE DATA TO THE PRIMARY INPUT FILE AT THIS
C       TIME WHETHER OR NOT AN UNSATURATED ZONE EXISTS.
C
C######################################################################
      AQVEL - GWHC * GWGR / GWEP
      WRITE (7,7490) AQVEL,DX,GWEP
7490  FORMAT (////,1X,79('-'),/,30X,'SATURATED ZONE DATA',/,1X,79('-')
     #    ,//,' AQUIFER VELOCITY - ',E10.4,'M/YR',/
     #    ' LONGITUDINAL DISPERSION COEFFICIENT - ',E10.4,' SQ M/YR',/
     #    ' AQUIFER EFFECTIVE POROSITY - ',E10.4,' CU M/CU M')
      WRITE (7,7491)
7491  FORMAT (//' CONTAMINANT',13X,'PULSE, YRS',4X,'RETAR FACT',2X,
     #    'LAMBDA, 1/YR',2X,'CONC, G/CU M')
      DO 32722 I-1,16
      SATRD - 1. + GWEBD * SKD(I) / GWEP
      IF(.NOT.(TTHIK .EQ. 0)) GO TO 32720
      CONCE - CL(I)
      GO TO 32721
32720 CONCE - CSAT(I)
32721 WRITE (7,751)(CHMNAM(J,I),J-1,5),PULSE(I),SATRD,SLAMBD(I),CONCE
751   FORMAT (1X,5A4,4(2X,E12.4))
32722 CONTINUE
C--------------------------
C WRITE "FLAG" INDICATOR FILE
C--------------------------
999   WRITE (1,*) IUNSAT,ISAT
      CLOSE (1)
      CLOSE (2)
      CLOSE (7)
      CLOSE (8)
      CLOSE (9)
      END
```

Appendix DD - Program CHAIN

```
$NOFLOATCALLS
$STORAGE:2
C
C     *******************************************************************
C     *                                          *
C     *       MULTI-ION SOLUTE TRANSPORT               CHAIN       *
C     *                                          *
C     *       FOUR SPECIES                                *
C     *       PREFERENTIAL RELEASE                        *
C     *                                          *
C     *       MAY,1982                                    *
C     *                                          *
C     *******************************************************************
C
      IMPLICIT real*4 (A-H,O-Z)
C      BYTE IANSR
      CHARACTER*64 IFILE
      COMMON R(4),DONE(4),RLAM(4),D,V,X,T,KSURF
      DIMENSION ZERO(4),GAMMA(4),TITLE(20),A(10),B(10)
C
C     CALL ERRSET(208,0,-1,1)
C-----------------------------------------------------------------
C  OPEN THE "FLAG" FILE AND CHECK TO SEE IF CHAIN NEEDS TO BE RUN
C-----------------------------------------------------------------
      OPEN (1,FILE='FLAG.FLG',STATUS='OLD')
      READ (1,*) IUNSAT
      CLOSE (1)
      IF (IUNSAT .EQ. 0) GOTO 1020
C-------------------------------------
C NOTIFY USER WHAT PROGRAM IS BEING RUN
C-------------------------------------
      WRITE (*,1100)
1100 FORMAT (//30X'PROGRAM:  CHAIN'/)
C
C---------------------------
C OPEN INPUT AND OUTPUT FILES
C---------------------------
C  100 WRITE(*,101)
C  101 FORMAT('$ENTER INPUT FILE NAME  > ')
C      ACCEPT 102,IFILE
C  102 FORMAT(A)
C
      OPEN(5,FILE='CHAIN.INP',STATUS='OLD')
C
C      WRITE(*,103)
C  103 FORMAT('$ENTER OUTPUT FILE NAME > ')
C      ACCEPT 102,IFILE
C
```

```
      OPEN(6,FILE='CHAIN.OUT',STATUS='NEW')
C
C      WRITE(*,104)
C  104 FORMAT('$DO YOU WANT A PLOT FILE ? (Y OR N) > ')
C      ACCEPT 105,IANSR
C  105 FORMAT(A1)
C      IF(IANSR.NE.'Y') GO TO 110
C      WRITE(*,106)
C  106 FORMAT('$ENTER PLOT FILE NAME > ')
C      ACCEPT 102,IFILE
C
C      OPEN(3,FILE=IFILE,STATUS='NEW')
C
C  110 CONTINUE
C
C      IF(IANSR.EQ.'Y') WRITE(3,1000) NC
C--------------------------------------
C BEGIN READING & PROCESSING INPUT FILE
C--------------------------------------
100   READ(5,1001,END=1020) TITLE
C
C     ----- READ INPUT PARAMETERS
      READ(5,1000) NS,NR,NB,KSURF,KDB,KPR,V,D,WC,TP
      READ(5,1002) (R(I),I=1,4),(DONE(I),I=1,4)
      READ(5,1002) (ZERO(I),I=1,4),(GAMMA(I),I=1,4)
      READ(5,1002) XI,DX,XM,TI,DT,TM
C      IF(IANSR.EQ.'Y') WRITE(3,1002) XI,DX,XM,TI,DT,TM
C
C     ----------
      DO 1 I=1,4
      ZERO(I)=NB*ZERO(I)
    1 RLAM(I)=NB*DONE(I)+GAMMA(I)
      IF(NB.EQ.0) GO TO 3
C
C     ----- CALCULATE BATEMAN EQUATIONS IF NB=1 -----
      Q=V*WC
      A(1)=ZERO(1)
      A(2)=DONE(1)*A(1)/(RLAM(2)-RLAM(1))
      A(3)=ZERO(2)-A(2)
      A(4)=DONE(2)*A(2)/(RLAM(3)-RLAM(1))
      A(5)=DONE(2)*A(3)/(RLAM(3)-RLAM(2))
      A(6)=ZERO(3)-A(4)-A(5)
      A(7)=DONE(3)*A(4)/(RLAM(4)-RLAM(1))
      A(8)=DONE(3)*A(5)/(RLAM(4)-RLAM(2))
      A(9)=DONE(3)*A(6)/(RLAM(4)-RLAM(3))
      A(10)=ZERO(4)-A(7)-A(8)-A(9)
      K=0
      DO 2 I=1,4
      DO 2 J=1,I
      K=K+1
    2 B(K)=A(K)*GAMMA(I)/Q
      GO TO 4
    3 READ(5,1002) (B(I),I=1,10)
C
C     ----- WRITE INPUT PARAMETERS -----
    4 IF(NS.LT.0) GO TO 14
      WRITE(6,1003)
      IF(KSURF.EQ.0) WRITE(6,1004)
      IF(KSURF.NE.0) WRITE(6,1005)
      WRITE(6,1006) TITLE
      WRITE(6,1007) NS,V,D,NR,WC,TP,NB
      WRITE(6,1008) (I,ZERO(I),R(I),DONE(I),GAMMA(I),RLAM(I),I=1,NS)
      WRITE(6,1009) (I,B(I),I=1,10)
C
C     ----- MULTIPLY DONE WITH R IF NR=1 -----
      IF(NR.EQ.0) GO TO 6
      DO 5 I=1,4
    5 DONE(I)=R(I)*DONE(I)
C
C     ----- CALCULATE VARIOUS CONSTANTS -----
    6 D12=DONE(1)-DONE(2)
      D13=DONE(1)-DONE(3)
      D23=DONE(2)-DONE(3)
      D14=DONE(1)-DONE(4)
      D24=DONE(2)-DONE(4)
      D34=DONE(3)-DONE(4)
      R12=R(1)-R(2)
      R13=R(1)-R(3)
      R23=R(2)-R(3)
      R14=R(1)-R(4)
      R24=R(2)-R(4)
      R34=R(3)-R(4)
      B123=-DONE(1)*R23+DONE(2)*R13-DONE(3)*R12
      B124=-DONE(1)*R24+DONE(2)*R14-DONE(4)*R12
      B134=-DONE(1)*R34+DONE(3)*R14-DONE(4)*R13
      B234=-DONE(2)*R34+DONE(3)*R24-DONE(4)*R23
      DD=DONE(1)*DONE(2)
      DP=DONE(2)*DONE(3)
      DDD=DD*DONE(3)
      C21=DONE(1)*B(1)/(D12-R12*RLAM(1))
      C31=DONE(2)*B(2)/(D23-R23*RLAM(1))
      C32=DONE(2)*B(3)/(D23-R23*RLAM(2))
      C331=DD*B(1)*R12/(B123*(R12*RLAM(1)-D12))
      C332=DD*B(1)*R13/(B123*(R13*RLAM(1)-D13))
      C333=DD*B(1)*R23/(B123*(R23*RLAM(1)-D23))
      C41=DONE(3)*B(4)/(D34-R34*RLAM(1))
      C42=DONE(3)*B(5)/(D34-R34*RLAM(2))
      C43=DONE(3)*B(6)/(D34-R34*RLAM(3))
      C441=DP*B(2)*R34/(B234*(R34*RLAM(1)-D34))
      C442=DP*B(2)*R23/(B234*(R23*RLAM(1)-D23))
      C443=DP*B(2)*R24/(B234*(R24*RLAM(1)-D24))
      C451=DP*B(3)*R34/(B234*(R34*RLAM(2)-D34))
      C452=DP*B(3)*R23/(B234*(R23*RLAM(2)-D23))
      C453=DP*B(3)*R24/(B234*(R24*RLAM(2)-D24))
      C461=DDD*B(1)*R14**2/(B134*B124*(R14*RLAM(1)-D14))
      C462=DDD*B(1)*R24**2/(B124*B234*(R24*RLAM(1)-D24))
      C463=DDD*B(1)*R34**2/(B134*B234*(R34*RLAM(1)-D34))
      C464=DDD*B(1)*R13**2/(B123*B134*(R13*RLAM(1)-D13))
      C465=DDD*B(1)*R23**2/(B123*B234*(R23*RLAM(1)-D23))
      C466=DDD*B(1)*R12**2/(B123*B124*(R12*RLAM(1)-D12))
C
C     ----- PRINT COEFFICIENTS IF KDB.GT.0 -----
      IF(KDB.GT.0) WRITE(6,1010) C21,C31,C32,C331,C332,C333,C41,C42,C43
     1,C441,C442,C443,C451,C452,C453,C461,C462,C463,C464,C465,C466
      F12=0.
      F13=0.
      F23=0.
      F32=0.
      F14=0.
      F24=0.
      F42=0.
      F34=0.
      F43=0.
      F44=0.
      E=0.
      P12=ABS(1000.*R12/R(1))
      P13=ABS(1000.*R13/R(1))
      P23=ABS(1000.*R23/R(2))
      P14=ABS(1000.*R14/R(1))
      P24=ABS(1000.*R24/R(2))
      P34=ABS(1000.*R34/R(3))
      IF(DX.EQ.0.) DX=1.0
      IF(DT.EQ.0.) DT=1.0
      IMAX=(XM+DX-XI)/DX
      JMAX=(TM+DT-TI)/DT
C-------------------------------------------------
C INITIALIZE THE CONC'S TO 0 FOR SUBSEQUENT INPUT SETS
C-------------------------------------------------
      CONC1 = 0.
      CONC2 = 0.
      CONC3 = 0.
      CONC4 = 0.
C-------------------------------------
C     ----- DYNAMIC PART OF PROGRAM -----
```

```
C--------------------------------------
      DO 12 JJ=1,JMAX
      IF(IMAX.GE.JJ) WRITE(6,1011)
      TIME=TI+(JJ-1)*DT
      DO 12 II=1,IMAX
      X=XI+(II-1)*DX
      VVO=0.0
      IF(X.EQ.0.) GO TO 7
      VVO=V*TIME/X
    7 DO 10 KK=1,2
      C1=0.0
      C2=0.0
      C3=0.0
      C4=0.0
      E1=1.0
      E2=1.0
      E3=1.0
      E4=1.0
      T=TIME+(1-KK)*TP
      IF(T.LE.0.) GO TO 10
      IF(KK.EQ.1) GO TO 8
      E1=EXF(-RLAM(1)*TP,E)
      E2=EXF(-RLAM(2)*TP,E)
      E3=EXF(-RLAM(3)*TP,E)
      E4=EXF(-RLAM(4)*TP,E)
    8 F110=F(1,0)*E1
C
C     ----- FIRST TRACER -----
      C1=B(1)*F110
      IF(NS.EQ.1) GO TO 9
C
C     ----- SECOND TRACER -----
      F220=F(2,0)*E2
      F210=F(2,-1)*E1
      IF(P12.GT.1.) F12=F(1,2)*E1
      C2=B(2)*F210+B(3)*F220+C21*(F210-F110-F12)
      IF(NS.EQ.2) GO TO 9
C
C     ----- THIRD TRACER -----
      F310=F(3,-1)*E1
      F320=F(3,-2)*E2
      F330=F(3,0)*E3
      IF(P13.GT.1.) F13=F(1,3)*E1
      IF(P23.GT.1.) F23=F(2,3)
      F32=F23*E2
      F23=F23*E1
      IF(KDB.EQ.2) WRITE(6,1012) F110,F210,F220,F12,F310,F320,F330,F13,F
     123,F32
```

```
      C3=B(4)*F310+B(5)*F320+B(6)*F330+C31*(F310-F210-F23)+C32*(F320-F22
     10-F32)+C331*(F210-F110-F12)+C332*(F13-F310+F110)+C333*(F310-F210-F
     223)
      IF(NS.EQ.3) GO TO 9
C
C     ----- FOURTH TRACER -----
      F410=F(4,-1)*E1
      F420=F(4,-2)*E2
      F430=F(4,-3)*E3
      F440=F(4,0)*E4
      IF(P14.GT.1.) F14=F(1,4)*E1
      IF(P24.GT.1.) F24=F(2,4)
      IF(P34.GT.1.) F34=F(3,4)
      F42=F24*E2
      F24=F24*E1
      F43=F34*E3
      F44=F34*E2
      F34=F34*E1
      IF(KDB.EQ.2) WRITE(6,1013) F410,F420,F430,F440,F14,F24,F42,F34,F4
     1,F44
      C4=B(7)*F410+B(8)*F420+B(9)*F430+B(10)*F440+C41*(F410-F310-F34)+C4
     12*(F420-F320-F44)+C43*(F430-F330-F43)+C441*(F410-F310-F34)+C442*(F
     2310-F210-F23)+C443*(F24-F410+F210)+C451*(F420-F320-F44)+C452*(F320
     3-F220-F32)+C453*(F42-F420+F220)+C461*(F110-F410+F14)+C462*(F410-F2
     410-F24)+C463*(F34-F410+F310)+C464*(F310-F110-F13)+C465*(F23-F310+F
     5210)+C466*(F12-F210+F110)
    9 IF(KK.EQ.2) GO TO 10
      CONC1=C1
      CONC2=C2
      CONC3=C3
      CONC4=C4
   10 CONTINUE
      CONC1=CONC1-C1
      CONC2=CONC2-C2
      CONC3=CONC3-C3
      CONC4=CONC4-C4
C
      CONC4=CONC4-C4
C       IF(IANSR.EQ.'Y') WRITE(3,1014) X,TIME,VVO,CONC1,CONC2,CONC3,CONC4
      IF(KPR.EQ.0) WRITE(6,1014) X,TIME,VVO,CONC1,CONC2,CONC3,CONC4
   12 IF(KPR.EQ.1) WRITE(6,1015) X,TIME,VVO,CONC1,CONC2,CONC3,CONC4
   14 GO TO 100
C
C
  998 WRITE(*,999)
  999 FORMAT(' ***** ERROR OPENING INPUT FILE *****')
      STOP
C
```

```
C     ----------
 1000 FORMAT(6I5,5F10.0)
 1001 FORMAT(20A4)
 1002 FORMAT(8F10.0)
 1003 FORMAT(1H1,10X,82(1H*)/11X,1H*,80X,1H*/11X,1H*,9X,'MULTI-ION SOLUT
     1E TRANSPORT',30X,'CHAIN',10X,1H*/11X,1H*,80X,1H*/11X,1H*,9X,'FOUR
     2SPECIES',59X,1H*/11X,1H*,9X,'PREFERENTIAL RELEASE',51X,1H*/11X,1H*
     3,80X,1H*)
 1004 FORMAT(11X,1H*,9X,'FIRST-TYPE BOUNDARY CONDITION',42X,1H*)
 1005 FORMAT(11X,1H*,9X,'THIRD-TYPE BOUNDARY CONDITION',42X,1H*)
 1006 FORMAT(11X,1H*,80X,1H*/11X,1H*,20A4,1H*/11X,1H*,80X,1H*/11X,82(1H*
     1))
 1007 FORMAT(//11X,'INPUT PARAMETERS'/11X,16(1H=)//11X,'NS =',I5,10X,'V
     1=',F12.4,10X,'D =',F12.4/11X,'NR =',I5,10X,'WC =',F11.4,10X,'TP ='
     2,G11.4/11X,'NB =',I5)
 1008 FORMAT(///9X,'TRACER',7X,'ZERO',13X,'R',11X,'DONE',11X,'GAMMA',11X
     1,'RLAM'//(11X,I2,D16.5,F14.3,3F15.8))
 1009 FORMAT(///11X,'B(I)-COEFFICIENTS'/11X,17(1H=)//11X,4('I',9X,'B(I)'
     1,9X)/(10X,4(I2,D15.6,6X)))
 1010 FORMAT(//9X,'C21= ',D13.5,6X,'C31= ',D13.5,6X,'C32= ',D13.5/9X,
     1'C331= ',D12.5,6X,'C332= ',D12.5,6X,'C333= ',D12.5/9X,'C41= ',
     2D13.5,6X,'C42= ',D13.5,6X,'C43= ',D13.5/9X,'C441= ',D12.5,6X,
     3'C442= ',D12.5,6X,'C443= ',D12.5/9X,'C451= ',D12.5,6X,'C452= ',
     4D12.5,6X,'C453= ',D12.5/9X,'C461= ',D12.5,6X,'C462= ',D12.5,6X,
     5'C463= ',D12.5/9X,'C464= ',D12.5,6X,'C465= ',D12.5,6X,'C466= ',
     6D12.5)
 1011 FORMAT(///8X,'DISTANCE',6X,'TIME',7X,'PORE VOLUME',4X,19(1H-),'CON
     1CENTRATION',19(1H-)/11X,'(X)',8X,'(T)',9X,'(VVO)',11X,'(1)',11X,'(
     22)',11X,'(3)',11X,'(4)')
 1012 FORMAT(//9X,'F110= ',D12.5,4X,'F210= ',D12.5,4X,'F220= ',D12.5/9X,
     1'F12= ',D13.5,4X,'F310= ',D12.5,4X,'F320= ',D12.5/9X,'F330= ',D12.
     25,4X,'F13= ',D13.5,4X,'F23= ',D13.5/9X,'F32= ',D13.5)
 1013 FORMAT(//9X,'F410= ',D12.5,4X,'F420= ',D12.5,4X,'F430= ',D12.5/9X,
     1'F440= ',D12.5,4X,'F14= ',D13.5,4X,'F24= ',D13.5/9X,'F42= ',D13.5,
     24X,'F34= ',D13.5,4X,'F43= ',D13.5/9X,'F44= ',D13.5)
C1014 FORMAT(2X,3F13.3,2X,4F14.5)
C1015 FORMAT(2X,3F13.3,2X,4D14.5)
 1014 FORMAT(2X,1P3E13.3,2X,4E14.3)
 1015 FORMAT(2X,1P3E13.3,2X,4E14.3)
C
 1020 CONTINUE
      CLOSE(UNIT=5)
      CLOSE(UNIT=6)
C      IF(IANSR.EQ.'Y') CLOSE(UNIT=3)
      WRITE(*,1021)
 1021 FORMAT(' ***** PROGRAM CHAIN FINISHED *****')
      STOP
      END
```

Appendix DD - Program CHAIN

```
      FUNCTION F(I,JJ)
C
C     PURPOSE: TO CALCULATE FIJK-TERMS
C
      IMPLICIT real*4 (A-H,O-Z)
      COMMON R(4),DONE(4),RLAM(4),D,V,X,T,KSURF
C
C     ----------
      J=IABS(JJ)
      IF(JJ.LT.0) A=RLAM(J)
      IF(JJ.EQ.0) A=RLAM(I)
      IF(JJ.GT.0) A=(DONE(I)-DONE(J))/(R(I)-R(J))
      U2=V*V+4.*D*(DONE(I)-A*R(I))
      S1=2.*SQRT(D*R(I)*T)
      U=SQRT(ABS(U2))
      VT=V*T
      UT=U*T
      E=0.0
C
C     ----- CASE FOR POSITIVE VALUES OF U2 -----
      IF(U2.LT.0.) GO TO 28
      AM=0.5*(V-U)*X/D-A*T
      BM1=(R(I)*X-UT)/S1
      BP1=(R(I)*X+UT)/S1
      AP=0.5*(U+V)*X/D-A*T
      IF(KSURF.EQ.0) GO TO 20
C
C     ----- CASE FOR THIRD-TYPE BOUNDARY CONDITION -----
      CP1=(R(I)*X+VT)/S1
      ALP=.3275911
      CM1=(R(I)*X-VT)/S1
      DUV=ABS(1.-U/V)
      IF((BP1.GT.4.).AND.(CP1.GT.4.)) GO TO 4
      IF((BP1.LT.2.5).AND.(CP1.LT.2.5)) GO TO 2
      IF(DUV.GT.0.1) GO TO 1
      IF(CP1.GT.3.) GO TO 4
      GO TO 2
    1 E1=2./((U/V)**2-1.)
      G1=V*X/D-DONE(I)*T/R(I)
      F1=V/(U-V)*EXF(AP,BP1)-E1*EXF(G1,CP1)
      GO TO 6
    2 D1=-CM1**2-DONE(I)*T/R(I)
      BETA=ALP*V*SQRT(T/(D*R(I)))
      T1=1./(1.+ALP*BP1)
      T2=1./(1.+ALP*CP1)
      C1=T1*T2*(1.+ALP*CM1)
      C2=T1*(C1-BETA*T2**2)
      C3=T1*(C2-BETA*T2**3)
      C4=T1*(C3-BETA*T2**4)
      C5=T1*(C4-BETA*T2**5)
      F1=V*(.2548296*C1-.2844967*C2+1.421414*C3-1.453152*C4+1.061405*C5)
     1*EXF(D1,E)/(V+U)
      GO TO 6
    4 B=DONE(I)*T/R(I)+CM1**2
      H=1./(BP1*(R(I)*X+VT))
      WT=H*VT
      HT=H*UT
      B1=WT+2.*HT
      B2=WT*B1+2.*HT**2
      B3=WT*B2+2.*HT**3
      B4=WT*B3+2.*HT**4
      B5=WT*B4+2.*HT**5
      B6=WT*B5+2.*HT**6
      B7=WT*B6+2.*HT**7
      B8=WT*B7+2.*HT**8
      Z1=H*R(I)*X
      Z2=Z1**2
      Z3=Z1*Z2
      Z4=Z1*Z3
      Z5=Z1*Z4
      Z6=Z1*Z5
      Z7=Z1*Z6
      Z8=Z1*Z7
      Z9=Z1*Z8
      A1=Z1-WT
      A2=Z3-WT*(B2+3.*(B1*Z1+Z2))
      A3=Z5-WT*(B4+5.*(B3*Z1+Z4)+10.*(B2*Z2+B1*Z3))
      A4=Z7-WT*(B6+7.*(B5*Z1+Z6)+21.*(B4*Z2+B1*Z5)+35.*(B3*Z3+B2*Z4))
      A5=Z9-WT*(B8+9.*(B7*Z1+Z8)+36.*(B6*Z2+B1*Z7)+84.*(B5*Z3+B2*Z6)+126
     1.*(B4*Z4+B3*Z5))
      F1=.5641896*V*EXF(-B,E)*(A1-.5*A2+.75*A3-1.875*A4+6.5625*A5)/(U+V)
    6 IF(JJ.GT.0) GO TO 8
      F=V/(V+U)*EXF(AM,BM1)-F1
      RETURN
    8 S2=2.*SQRT(D*R(J)*T)
      BM2=(R(J)*X-UT)/S2
      BP2=(R(J)*X+UT)/S2
      CP2=(R(J)*X+VT)/S2
      CM2=(R(J)*X-VT)/S2
      IF((BP2.GT.4.).AND.(CP2.GT.4.)) GO TO 14
      IF((BP2.LT.2.5).AND.(CP2.LT.2.5)) GO TO 10
      IF(DUV.GT.0.1) GO TO 9
      IF(CP2.GT.3.) GO TO 14
      GO TO 10
    9 E2=2./((U/V)**2-1.)
      G2=V*X/D-DONE(J)*T/R(J)
      AP=0.5*(V+U)*X/D-A*T
      F2=V/(U-V)*EXF(AP,BP2)-E2*EXF(G2,CP2)
      GO TO 18
   10 D2=-CM2**2-DONE(J)*T/R(J)
      BETA=ALP*V*SQRT(T/(D*R(J)))
      T1=1./(1.+ALP*BP2)
      T2=1./(1.+ALP*CP2)
      C1=T1*T2*(1.+ALP*CM2)
      C2=T1*(C1-BETA*T2**2)
      C3=T1*(C2-BETA*T2**3)
      C4=T1*(C3-BETA*T2**4)
      C5=T1*(C4-BETA*T2**5)
      F2=V*(.2548296*C1-.2844967*C2+1.421414*C3-1.453152*C4+1.061405*C5)
     1*EXF(D2,E)/(V+U)
      GO TO 16
   14 B=DONE(J)*T/R(J)+CM2**2
      H=1./(BP2*(R(J)*X+VT))
      WT=H*VT
      HT=H*UT
      B1=WT+2.*HT
      B2=WT*B1+2.*HT**2
      B3=WT*B2+2.*HT**3
      B4=WT*B3+2.*HT**4
      B5=WT*B4+2.*HT**5
      B6=WT*B5+2.*HT**6
      B7=WT*B6+2.*HT**7
      B8=WT*B7+2.*HT**8
      Z1=H*R(J)*X
      Z2=Z1**2
      Z3=Z1*Z2
      Z4=Z1*Z3
      Z5=Z1*Z4
      Z6=Z1*Z5
      Z7=Z1*Z6
      Z8=Z1*Z7
      Z9=Z1*Z8
      A1=Z1-WT
      A2=Z3-WT*(B2+3.*(B1*Z1+Z2))
      A3=Z5-WT*(B4+5.*(B3*Z1+Z4)+10.*(B2*Z2+B1*Z3))
      A4=Z7-WT*(B6+7.*(B5*Z1+Z6)+21.*(B4*Z2+B1*Z5)+35.*(B3*Z3+B2*Z4))
      A5=Z9-WT*(B8+9.*(B7*Z1+Z8)+36.*(B6*Z2+B1*Z7)+84.*(B5*Z3+B2*Z6)+126
     1.*(B4*Z4+B3*Z5))
      F2=.5641896*V*EXF(-B,E)*(A1-.5*A2+.75*A3-1.875*A4+6.5625*A5)/(U+V)
   16 IF((BM1.GT.0.).OR.(BM2.GT.0.)) GO TO 18
      Q=-BM2
      BM2=-BM1
      BM1=Q
   18 F=V/(V+U)*(EXF(AM,BM2)-EXF(AM,BM1))+F1-F2
```

```
      RETURN
C
C     ----- CASE FOR FIRST-TYPE BOUNDARY CONDITION -----
   20 IF(JJ.GT.0) GO TO 22
      F=0.5*(EXF(AM,BM1)+EXF(AP,BP1))
      RETURN
   22 S2=2.*SQRT(D*R(J)*T)
      BM2=(R(J)*X-UT)/S2
      BP2=(R(J)*X+UT)/S2
      IF((BM1.GT.0.).OR.(BM2.GT.0.)) GO TO 24
      Q=-BM2
      BM2=-BM1
      BM1=Q
   24 F=0.5*(EXF(AM,BM2)-EXF(AM,BM1)+EXF(AP,BP2)-EXF(AP,BP1))
      RETURN
C
C     ----- CASE FOR NEGATIVE VALUES OF U2 -----
   28 AM=0.5*V*X/D-A*T
      ARG=0.5*U*X/D
      CS=COS(ARG)
      SN=SIN(ARG)
      A1=R(I)*X/S1
      A2=UT/S1
      CALL CEXF(A1,A2,AM,X1,Y1)
      IF(KSURF.EQ.0) GO TO 32
      CP1=(R(I)*X+VT)/S1
      CM1=V*X/D-DONE(I)*T/R(I)
      C1=2.*V/(V*V-U2)
      C2=0.5*V*V/(D*(DONE(I)-A*R(I)))
      IF(JJ.GT.0) GO TO 30
      F=C1*(CS*(X1*V-Y1*U)-SN*(X1*U+Y1*V))+C2*EXF(CM1,CP1)
      RETURN
   30 CONTINUE
      S2=2.*SQRT(D*R(J)*T)
      CM2=V*X/D-DONE(J)*T/R(J)
      C3=0.5*V*V/(D*(DONE(J)-A*R(J)))
      CP2=(R(J)*X+VT)/S2
      A1=R(J)*X/S2
      A2=UT/S2
      CALL CEXF(A1,A2,AM,X2,Y2)
      F=C1*(CS*(V*(X2-X1)-U*(Y2-Y1))-SN*(U*(X2-X1)+V*(Y2-Y1)))+C3*EXF(CM
     12,CP2)-C2*EXF(CM1,CP1)
      RETURN
   32 IF(JJ.GT.0) GO TO 34
      F=CS*X1-SN*Y1
      RETURN
   34 S2=2.*SQRT(D*R(J)*T)
      A1=R(J)*X/S2
      A2=UT/S2
      CALL CEXF(A1,A2,AM,X2,Y2)
      F=CS*(X2-X1)-SN*(Y2-Y1)
      RETURN
      END
      FUNCTION EXF(A,B)
C
C     PURPOSE: TO CALCULATE EXP(A) ERFC(B)
C
      IMPLICIT real*4 (A-H,O-Z)
      EXF=0.0
      IF((ABS(A-B*B).GT.100.).AND.(B.GT.0.)) RETURN
      IF((ABS(A).GT.100.).AND.(B.LE.0.)) RETURN
      IF(B.NE.0.0) GO TO 1
      EXF=exp(A)
      RETURN
    1 C=A-B*B
      IF((ABS(C).GT.170.).AND.(B.GT.0.)) RETURN
      IF(C.LT.-170.) GO TO 4
      X=ABS(B)
      IF(X.GT.2.5) GO TO 2
      T=1./(1.+.3275911*X)
      Y=T*(.2548296-T*(.2844967-T*(1.421414-T*(1.453152-1.061405*T))))
      GO TO 3
    2 Y=.5641896/(X+.5/(X+1./(X+1.5/(X+2./(X+2.5/(X+3./(X+1.)))))))
    3 EXF=Y*exp(C)
    4 IF(B.LT.0.0) EXF=2.*exp(A)-EXF
      RETURN
      END
      SUBROUTINE CEXF(A,B,Z,U,V)
C
C     COMPLEX ERFC-FUNCTION: U+IV=EXP(Z)ERFC(A+IB)
C
      IMPLICIT REAL*4 (A-H,O-Z)
      DIMENSION W(10),H(10)
      DATA W/.4622437,.2866755,.1090172,.02481052,.3243773E-2,
     1.2283386E-3,.7802556E-5,.1086069E-6,.4399341E-9,.2229394E-12/,
     2H/.2453407,.7374737,1.234076,1.738538,2.254974,
     32.788806,3.347855,3.944764,4.603682,5.387481/
C
C     ----------
      X=ABS(A)
      Y=ABS(B)
      U=0.0
      V=0.0
      E=0.0
      XYZ=Y*Y+Z-X*X
      IF(ABS(XYZ).GT.170.)RETURN
```

```
  xCOS=COS(2.*X*Y)
  xSIN=SIN(2.*X*Y)
  IF((X+Y).LT.6.) GO TO 2
  T=0.0
  DO 1 K=1,10
  T=T+W(K)*((X/((Y-H(K))**2+X*X))+(X/((Y+H(K))**2+X*X)))
1 V=V+W(K)*((Y-H(K))/((Y-H(K))**2+X*X)+(Y+H(K))/((Y+H(K))**2+X*X))
  U=.3183099*exp(XYZ)*(T*xCOS-V*xSIN)
  V=.3183099*exp(XYZ)*(-T*xSIN-V*xCOS)
  if(x.eq.0.and.z.gt.170.0) zz=170.0
  IF(X.EQ.0.)U=exp(Zz)
  GO TO 8
2 IF(X.GT.2.5) GO TO 3
  T=1./(1.+.3275911*X)
  U=T*(.2548296-T*(.2844967-T*(1.421414-T*(1.453152-1.061405*T))))
  GO TO 4
3 U=.5641896/(X+.5/(X+1./(X+1.5/(X+2./(X+2.5/(X+3./(X+1.)))))))
4 IF(Y.EQ.0.) GO TO 7
  IF(X.EQ.0.) V=-.3183099*Y
  IF(X.EQ.0.) GO TO 5
  U=U-.1591549*(1.D0-xCOS)/X
  V=V-.1591549*xSIN/X
5 NT=12.+2.*Y
  DO 6 I=1,NT
  P=I
  ARG=P*Y
  F1=X*(exp(ARG)+exp(-ARG))
  F2=0.5*P*(exp(ARG)-exp(-ARG))
  EX=.6366198*exp(-0.25*P*P)/(4.*X*X+P*P)
  U=U-EX*(2.*X-F1*xCOS+F2*xSIN)
6 V=V-EX*(F1*xSIN+F2*xCOS)
  V=V*exp(Z-X*X)
7 U=U*exp(Z-X*X)
8 IF(B.LT.0.) V=-V
  IF(A.LT.0.) U=2.*EXF(Z,E)-U
  RETURN
  END
```

Appendix EE - Program AT123IN

```
$NOFLOATCALLS
$STORAGE:2
C######################################################################
C   AT123IN.FLX    -    DEC 1987
C
C   PROGRAM TO READ OUTPUT FROM CHAIN PROGRAM
C      AND GENERATE INPUT FILE FOR AT123D.
C######################################################################
      DIMENSION T(100),C(100)
C      DIMENSION AS(28),CD(35),CU(28),PB(35),HG(28),RNI(28)
      DIMENSION CHEM(54,6),NV(6)
      DIMENSION CHMNAM(5)
C----------------------------------------------------------------------
C   DATA STATEMENTS
C
C   ENTER THE MINTEQ DATA FOR THE 5 METALS:
C----------------------------------------------------------------------
C 1) ARSENIC
C       DATA AS /.06,1.27,2.54,5.06,
C      #     1.98E-11,2.29E-11,2.71E-11,4.09E-11
C      #     2.4E-04,1.06,2.19,4.43,
C      #     2.47E-04,1.19,2.46,5.0,
C      #     5.91E-11,6.83E-11,8.12E-11,1.22E-10,
C      #     6.07E-02,1.27,2.54,5.06,
C      #     6.91E-06,1.19,2.46,4.99/
C 2) CADMIUM
C       DATA CD /8.900E-08,1.11E-06,2.22E-06,4.44E-06,4.44E-04,
C      #     8.998E-08,1.112E-06,2.224E-06,4.449E-06,4.407E-04,
C      #     8.900E-08,1.095E-06,2.208E-06,4.432E-06,4.440E-04,
C      #     8.900E-08,1.095E-06,2.208E-06,4.432E-06,4.440E-04,
C      #     8.998E-08,1.112E-06,2.224E-06,4.449E-06,4.407E-04,
C      #     8.900E-08,1.095E-06,2.208E-06,4.432E-06,4.440E-04,
C      #     8.900E-08,1.095E-06,2.208E-06,4.432E-06,4.440E-04/
C 2) COPPER
C       DATA CU /1.32,32.5,65.4,130.,
C      #     1.58E-08,2.0E-07,2.04E-07,2.04E-07,
C      #     0.162,0.162,0.162,0.162,
C      #     1.09,3.08,3.15,3.34,
C      #     7.88E-07,1.9E-06,1.9E-06,1.9E-06,
C      #     0.15,0.15,0.15,0.15,
C      #     0.269,0.269,0.269,0.269/
C 3) LEAD
C       DATA PB /0.03,0.499,1.0,2.0,10.,
C      #     2.01E-11, 2.03E-11, 2.05E-11, 2.09E-11, 4.02E-11,
C      #     1.36E-07,      0.402,       0.901,     1.9,      9.89,
C      #     1.35E-07,      0.402,       0.901,     1.9,      9.89,
C      #     2.41E-12, 2.43E-12, 2.46E-12, 2.50E-12, 2.96E-11,
C      #     1.06E-07,      0.402,       0.901,     1.9,      9.89,
C     #    1.05E-07,      0.402,       0.901,     1.9,      9.67/
C 4) MERCURY
C       DATA HG /3.51E-03,7.52E-02,0.15,0.301,
C     #    4.59E-07,4.61E-07,4.61E-07,4.63E-07,
C     #    1.75E-03,2.43E-02,2.43E-02,2.43E-02,
C     #    3.41E-03,6.82E-02,.137,.243,
C     #    6.86E-08,6.86E-08,6.86E-08,6.86E-08,
C     #    1.83E-03,2.43E-02,2.43E-02,2.43E-02,
C     #    2.13E-04,2.13E-04,2.13E-04,2.13E-04/
C 5) NICKEL.
C       DATA RNI /.159,3.75,7.46,15.0,4.3E-05,5.65E-05,8.4E-05,3.22E-03,
C     #    0.16,3.75,7.51,15.0,0.16,3.75,7.51,15.0,
C     #    4.33E-06,5.69E-06,8.45E-06,3.45E-04,0.16,3.75,7.51,15.0,
C     #    0.16,3.75,7.51,15.0/
C
C########################################################################
C
C OPEN THE "FLAG" FILE & CHECK TO SEE WHAT PROGRAMS SHOULD BE RUN
C-----------------------------------------------------------------
       OPEN (1,FILE='FLAG.FLG',STATUS='OLD')
       READ (1,*) IUNSAT,ISAT
       CLOSE (1)
       IF (ISAT.EQ.0) THEN
      OPEN (2,FILE='SAT.INP',STATUS='NEW')
      C0 = 0.
      C1 = 0.
      DO 5 I=1,16
        WRITE (2,60) C0,C1
5     CONTINUE
      CLOSE (2)
      STOP
       END IF
C
C READ SORPTION DATA FROM "SLUDGN.SOR"
C
      OPEN (1,FILE='SLUDGN.SOR',STATUS='OLD')
      READ (1,*) NV
      READ (1,*) ((CHEM(J,I),J=1,54),I=1,6)
      CLOSE (1)
C-----------------------------------------------------------------
C OPEN THE APPROPRIATE INPUT & OUTPUT FILES
C
C OPEN 1 : CHAIN.OUT   - THE CHAIN MODEL OUTPUT FILE.
C      2 : SAT.INP     - FILE OF LEACH CONC'S INTO SATURATED ZONE
C      8 : AT123D.TMP  - TEMPORARY INPUT FILE CREATED BY SLUDGEMAN.
C      9 : AT123D.INP  - FINAL AT123D MODEL INPUT FILE
C-----------------------------------------------------------------
      IF(IUNSAT.EQ.1) OPEN (1,FILE='CHAIN.OUT',STATUS='OLD')
      OPEN (2,FILE-'SAT.INP',STATUS-'NEW')
      OPEN (8,FILE-'AT123D.TMP',STATUS-'OLD')
      OPEN (9,FILE-'AT123D.INP',STATUS-'NEW')
C---------------------------------------------
C NOTIFY THE USER AS TO WHAT PROGRAM IS BEING RUN
C---------------------------------------------
      WRITE (*,1)
1     FORMAT (//20X' PROGRAM:  AT123IN'//
     # '     THIS PROGRAM READS THE OUTPUT FROM "CHAIN" AND DETERMINES'/
     # ' THE APPROPRIATE PERIOD OF TIME AND CONCENTRATION FOR CHEMICAL'/
     # ' INFLUX TO THE SATURATED ZONE.'///)
C-----------------------------------------------------------------------
C   IF AN UNSATURATED ZONE EXISTS, THEN READ THE RESULTS FROM THE CHAIN
C      MODEL RUN TO OBTAIN THE PEAK CONTAMINANT CONCENTRATION AND THE
C      PULSE DURATION AND USE THIS INFORMATION TO WRITE THE AT123D MODEL
C      INPUT FILE.
C-----------------------------------------------------------------------
       ICHEM - 0
       II - 0
32758  II - II + 1
C##################################################################=====
C
C   READ THE AT123D MODEL INPUT FILE THAT WAS WRITTEN IN THE SLUGMAIN
C      PROGRAM, AND THEN UPDATE THIS FILE WITH DATA FROM THE CHAIN
C      MODEL RESULTS.
C
C##################################################################=====
C
      READ (8,101,END-107) (CHMNAM(J),J-1,5),ATDDES
101   FORMAT (1X,5A4,4X,A60)
      READ (8,102) NX,NY,NZ,NROOT,NBGTI,NEDTI,NPRINT,
     #        INSTAN,NSOUS,INTER,ICASE,IWID,IDEP,IBUG,ICHEM,IPHEH
102   FORMAT (16I5)
      READ (8,103) DEPTH,STWID,RL1,RL2,RB1,RB2,RH1,RH2
103   FORMAT (8F10.2)
      READ (8,103) GWEP,GWHC,GWGR,DX,DY,DZ,SAKD,AKE
      READ (8,103) AMTAU,DECAY,GWEBD,RHOW,ACCU,DT,
     #       PULSE,Q
      READ (8,103) STLENP,STRC,CBACK,UNTIM
      READ (8,103) YDIM
      READ (8,103) ZDIM
C--------------------------------
C CHECK IF CHEM IS IN AT123D.TMP FILE
C--------------------------------
107   IF (ICHEM.NE.II) THEN
     NCHEM - ICHEM - II
     IF (NCHEM.LT.0) THEN
       DO 108 I-II,16
```

```
         WRITE (2,60) C0,C1
108    CONTINUE
       GO TO 999
     ELSE
     DO 109 I-1,NCHEM
       C0 - 0.
       C1 - 0.
       WRITE (2,60) C0,C1
109  CONTINUE
     II - ICHEM
     END IF
      END IF
C-----------------------------------------
C CHECK IF RESULTS OF CHAIN NEED TO BE READ
C-----------------------------------------
      UNTIM - 0.
      IF (IUNSAT.NE.1) GO TO 32756
C-------------------------------------------
C SKIP THE NEXT 41 LINES OF CHAIN OUTPUT FILE
C-------------------------------------------
      DO 32755 I-1,41
      READ(1,10,END-999)
32755 CONTINUE
C------------------------------
C READ TIME & CONCENTRATION DATA
C------------------------------
      DO 32754 I-1,1000
      READ(1,10,ERR-20,END-20) T(I),C(I)
10    FORMAT(15X,F13.3,15X,F14.5)
32754 CONTINUE
C---------------------------
C FIND THE PEAK CONCENTRATION
C---------------------------
20    IM1 - I - 1
      CMAX - C(1)
      IND - 1
      DO 32753 I-2,IM1
      IF(.NOT.(C(I).GT.CMAX)) GO TO 32752
      CMAX - C(I)
      IND - I
32752 CONTINUE
32753 CONTINUE
      UNTIM - T(IND)
C---------------------------------------------------------
C FIND THE TIME DURING WHICH THE CONCENTRATION EXCEEDS 0.01
C (1%) OF THE MAXIMUM CONCENTRATION
C---------------------------------------------------------
      CLIM - 0.01 * CMAX
      CSUM = 0.
      NT = 0
      DO 32751 I=1,IM1
      IF(.NOT.(C(I).GT.CLIM)) GO TO 32750
      CSUM = CSUM + C(I)
C NEED # DELTA TIMES IF WE INPUT A DISTRIBUTION TO AT123D
C     NT = NT + 1
C30    IF (I.EQ.1) WRITE(*,31) CHMNAM
C40    IF (I.EQ.IM1) WRITE(*,41) CHMNAM
32750 CONTINUE
32751 CONTINUE
C31    FORMAT(/' *** 1ST CONCENTRATION EXCEEDS 1% OF MAX ***'/
C     + 10X' FOR ',5A4/
C     + ' YOU MAY WISH TO ADJUST THE TIME PERIOD FOR WHICH'/
C     + ' CONCENTRATIONS ARE CALCULATED IN CHAIN'/)
C41    FORMAT(/' *** LAST CONCENTRATION EXCEEDS 1% OF MAX ***'/
C     + 10X' FOR ',5A4/
C     + ' YOU MAY WISH TO ADJUST THE TIME PERIOD FOR WHICH'/
C     + ' CONCENTRATIONS ARE CALCULATED IN CHAIN'/)
C CALCULATE THE PULSE TIME
      PULSE = CSUM/CMAX * ( T(2) - T(1) )
C####################################################################====
C
C   CALCULATE THE TIME STEPS INFORMATION AND WRITE IT BACK INTO THE
C      AT123D INPUT FILE.
C
C####################################################################====
C
C   CALCULATE THE SATURATED ZONE BULK (DARCIAN) WATER VELOCITY
32756        BLKVEL = GWHC * GWGR
C   CALCULATE RETARDATION FACTOR
      RET = 1 + GWEBD * SAKD / GWEP
C   CALCULATE THE CONTAMINANT VELOCITY
      PORVEL = BLKVEL / GWEP
      CNTVEL = PORVEL / RET
C   CALCULATE THE CONTAMINANT TRAVEL TIME THROUGH THE SATURATED ZONE.
      SITLEN = RL2 - RL1
      TTCONT = (STLENP-SITLEN) / CNTVEL
C####################################################################====
C
C   INTERPOLATE THE MINTEQ DATA FOR THE METALS ONLY.
C
C####################################################################====
      C0 = CMAX
      IF (IUNSAT.EQ.0) C0 = Q
      C1 = C0
C
      IF (ICHEM.LT.7) THEN
```

```
     IDIM = NV(ICHEM) * 9
     CALL CINT(CHEM(1,ICHEM),IDIM,C1,IPHEH)
      END IF
C
C WRITE TO SAT.INP FILE
C
      WRITE (2,60) C0,C1
60    FORMAT(1P2E12.3)
C-------------------------------------------------------
C NOW ADJUST THE PULSE TIME TO ACCOUNT FOR RE-DISSOLUTION
C OF THE CHEMICAL THAT PRECIPITATES.
C-------------------------------------------------------
32749 PULSE = C0/C1 * PULSE
C-------------------------------------------------------------
C CALCULATE THE FLUX FROM THE PSEUDO "REPOSITORY" AS THE AMOUNT
C OF THE SATURATED ZONE RECHARGE WASHED FROM THE "REPOSITORY"
C PER YEAR BY THE GROUNDWATER FLOW.
C    TOTAL RECHARGE = R * W * L
C    AMOUNT WASHED FROM REPOSITORY PER YEAR =
C          1    IF VEL * 1YEAR > L
C        VEL/L IF VEL * 1YEAR < L
C    TOTAL FLUX FROM "REPOSITORY" PER YEAR =
C        R * W * L  IF VEL > L
C        R * W * VEL IF VEL < L
C
C    TOTAL MASS FLUX = R * W * MIN(L,VEL) * C1
C
C ADJUST THE PULSE TIME FOR THE AMOUNT OF THE RECHARGE WASHED
C FROM THE "REPOSITORY" PER YEAR.  IF ONLY HALF THE RECHARGE
C IS WASHED OUT PER YEAR, THE PULSE TIME WILL BE DOUBLED.
C    W       = SITE WIDTH
C    EL = EFFECTIVE LENGTH
C--------------------------------------------------------------
      W  = RB2 - RB1
      EL = MIN (PORVEL,SITLEN)
      Q = STRC * W * EL * C1
      PULSE = PULSE * SITLEN/EL
C-----------------------------------------------------------
C SET TIME STEP TO MINIMUM OF TRAVEL TIME AND RELEASE TIME
C SET PRINT STEPS LARGER IF EITHER TRAVEL TIME OR RELEASE TIME
C    IS LARGE IN RELATION TO THE OTHER
C "INSTAN" = 1 FOR CONTINUOUS RELEASE, 0 FOR INSTANTANEOUS
C IF THE PULSE IS TOO SMALL IN RELATION TO THE TRAVEL TIME,
C    GO TO AN INSTANTANEOUS RELEASE OTHERWISE TOO MANY TIME
C    STEPS MUST BE CALCULATED RESULTING IN INORDINATE COMPUTATION
C    TIMES.  INSTANT RELEASE = Q * PULSE.
C-----------------------------------------------------------
      IF (INSTAN.EQ.0) GO TO 32742
      INSTAN = 1
      IF (PULSE .GT. TTCONT) GO TO 32740
      IF (PULSE .LT. 0.01*TTCONT) THEN
     INSTAN = 0
     GO TO 32742
      END IF
      DT = 0.1 * PULSE
      STEP = TTCONT/PULSE
      NBGTI = 8.*STEP
      NEDTI = 12.*STEP
      NPRINT = .2*STEP
      IF (STEP.GT.5.) GO TO 32739
      NBGTI = 10.*STEP
      NEDTI = 20.*STEP
      NPRINT = STEP
      GO TO 32739
32740 DT = 0.1*TTCONT
      IF (PULSE .GT. 100.*TTCONT) PULSE = 100.*TTCONT
      IF (PULSE .GT. 5*TTCONT) GO TO 500
      NBGTI = 11
      NEDTI = 61
      NPRINT = 2
      GO TO 32739
500   NBGTI = 51
      NEDTI = 101
      NPRINT = 5
      GO TO 32739
32742 Q = Q * PULSE
C#####################################################################
C
C   WRITE OUT THE FINAL AT123D INPUT FILE.
C
C#####################################################################
C
32739 WRITE (9,101) (CHMNAM(J),J=1,5),ATDDES
      WRITE (9,102) NX,NY,NZ,NROOT,NBGTI,NEDTI,NPRINT,
     #       INSTAN,NSOUS,INTER,ICASE,IWID,IDEP,IBUG
      WRITE (9,103) DEPTH,STWID,RL1,RL2,RB1,RB2,RH1,RH2
      WRITE (9,104) GWEP,GWHC,GWGR,DX,DY,DZ,SAKD,AKE
      WRITE (9,105) AMTAU,DECAY,GWEBD,RHOW,ACCU,DT,
     #       PULSE,Q
      WRITE (9,106) STLENP,CBACK,UNTIM
      WRITE (9,103) YDIM
      WRITE (9,103) ZDIM
      GO TO 32758
104   FORMAT(F10.2,1P7E10.3)
105   FORMAT(1P8E10.3)
106   FORMAT(F10.2,1P2E10.3)
```

```
C
999   CLOSE (1)
      CLOSE (2)
      CLOSE (8)
      CLOSE (9)
*     STOP
      END
C------------------------------------------------------------------
C FUNCTION TO INTERPOLATE THE MINTEQ DATA TO CALCULATE THE PROPER
C DISSOLVED CONCENTRATION CONSIDERING PRECIPITATION OF THE CHEMICAL
C------------------------------------------------------------------
      SUBROUTINE CINT(A,IDIM,C1,IPHEH)
C
C----------------------------------------------------------------
C A - ARRAY OF THE DESIRED CHEMICAL
C IDIM - DIMENSION OF THE ARRAY
C CO - CONCENTRATION OF CHEMICAL ENTERING THE SATURATED ZONE
C IPHEH - NUMBER INDICATING WHICH PH AND EH VALUES ARE CONSIDERED
C----------------------------------------------------------------
      DIMENSION A(IDIM)
C----------------------------------------------
C N - # OF MINTEQ DATA POINTS FOR THIS CHEMICAL
C----------------------------------------------
      NV - IDIM/9
      IF (C1.GT.A(1)) GO TO 32758
      I2 - IPHEH*NV + 1
      C1 - A(I2)/A(1) * C1
      RETURN
32758 I1 - 1
32757 IF(.NOT.(C1.GT.A(I1) .AND. I1.LT.NV)) GO TO 32756
      I1 - I1 + 1
      GO TO 32757
32756 I1 - I1 - 1
      I2 - IPHEH*NV + I1
      C1 - A(I2) + ( C1-A(I1) )/( A(I1+1)-A(I1) ) * ( A(I2+1)-A(I2) )
      IF (C1.LE.0) C1 - A(I2)
      RETURN
      END
```

Appendix FF - Program AT123D

```
$NOFLOATCALLS
$STORAGE:2
C
C      **************************************************************
C      *                                                            *
C      *  YEH G. T. 1979. ANALYTICAL SIMULATION OF WASTE TRANSPORT  *
C      *                                                            *
C      *    IN THE AQUIFER SYSTEM.  ORNL-    , OAK RIDGE NATIONAL   *
C      *                                                            *
C      *    LABORATORY, OAK RIDGE, TENNESSEE 37830                  *
C      *                                                            *
C      **************************************************************
C
C
C  TO SIMULATE THE WASTE (INCLUDING THERMAL, CHEMICAL, OR RADIOACTIVE)
C  TRANSPORT IN SATURATED AQUIFER BY ANALYTICAL METHOD
C  FOR ANY QUESTION ON THE PROGRAM CONTACT DR. G. T. YEH OF ORNL
C  AT (615) 574-7285
C*****************************************************
C    CHANGE 6/22/82
C
     IMPLICIT REAL*4 (A-H,O-Z)
C
C**********************************************************
C
$LARGE:FCTY,FCTZ,QS,AIY,AIZ,RTY,RTZ,PSIS,PHIS
      DIMENSION TITLE(20), XDIM(15),YDIM(10),ZDIM(10)
      DIMENSION TEMP(15,10,10),TEMPO(15,10,10)
      DIMENSION RTY(1000),AIY(1000),PSIS(1000),FCTY(10,1201)
C     DIMENSION RTY(1000),AIY(1000),PSIS(1000),FCTY(10,9901)
      DIMENSION RTZ(1000),AIZ(1000),PHIS(1000),FCTZ(10,1201)
C     DIMENSION RTZ(1000),AIZ(1000),PHIS(1000),FCTZ(10,9901)
      DIMENSION QS(1201)
C     DIMENSION QS(9901)
C
      DATA MAXNX,MAXNY,MAXNZ,MAXNTI,MAXRUT /15,10,10,1201,1000/
C     DATA MAXNX,MAXNY,MAXNZ,MAXNTI,MAXRUT /15,10,10,9901,1000/
C
C
C ------- ALL UNITS IN THIS PROGRAM ARE THE SI SYSTEM
C
C
C
      DO 100 I=1,MAXNX
      DO 100 J=1,MAXNY
         DO 100 K=1,MAXNZ
            TEMPO(I,J,K)=0.0
  100            TEMP(I,J,K)=0.0
```

```
C
      DO 210 I-1,MAXNX
  210      XDIM(I)-0.0
C
      DO 220 I-1,MAXNY
      YDIM(I)-0.0
      DO 220 J-1,MAXNTI
  220         FCTY(I,J)-0.0
C
      DO 230 I-1,MAXNZ
      ZDIM(I)-0.0
      DO 230 J-1,MAXNTI
  230         FCTZ(I,J)-0.0
C
      DO 300 I-1,MAXNTI
  300      QS(I)-1.0
C
      DO 400 I-1,MAXRUT
      RTY(I)-0.0
      AIY(I)-0.0
      RTZ(I)-0.0
  400      AIZ(I)-0.0
C
C
C ------- PASS THE PROGRAM TO AT123D
C
      CALL AT123D(TEMP,TEMPO,XDIM,YDIM,ZDIM,RTY,AIY,PSIS,FCTY,
     > RTZ,AIZ,PHIS,FCTZ,QS,TITLE,MAXNX,MAXNY,MAXNZ,MAXNTI,MAXRUT)
C
      STOP
      END
      SUBROUTINE AT123D(TEMP,TEMPO,XDIM,YDIM,ZDIM,RTY,AIY,PSIS,FCTY,
     > RTZ,AIZ,PHIS,FCTZ,QS,TITLE,MAXNX,MAXNY,MAXNZ,MAXNTI,MAXRUT)
C
C*****************************************************
C    CHANGE 6/22/82
C
     IMPLICIT REAL*4 (A-H,O-Z)
C
C**********************************************************
      DIMENSION TITLE(20),XDIM(MAXNX),YDIM(MAXNY),ZDIM(MAXNZ)
      DIMENSION TEMP(MAXNX,MAXNY,MAXNZ),TEMPO(MAXNX,MAXNY,MAXNZ)
      DIMENSION RTY(MAXRUT),AIY(MAXRUT),PSIS(MAXRUT),FCTY(MAXNY,MAXNTI)
      DIMENSION RTZ(MAXRUT),AIZ(MAXRUT),PHIS(MAXRUT),FCTZ(MAXNZ,MAXNTI)
      DIMENSION QS(MAXNTI)
C
      DATA CP,PAI/1.0,3.141593/
C--------------------------
```

```
C OPEN INPUT AND OUTPUT FILES
C---------------------------
      OPEN (5,FILE-'AT123D.INP',STATUS-'OLD')
      OPEN (6,FILE-'AT123D.OUT',STATUS-'NEW')
C
C ------- READ IN TITLE, SYSTEM PARAMETERS, AND CONTROL INPUTS
C
C
  999 READ(5,10,END-9999) TITLE
      READ(5,20) NX,NY,NZ,NROOT,NBGTI,NEDTI,NPRINT,INSTAN,NSOURS,INTER,
     1 ICASE,IWID,IDEP,IBUG
      READ(5,30) DEPTH,WIDTH,RL1,RL2,RB1,RB2,RH1,RH2
      READ(5,30) POR,HCOND,HGRAD,AELONG,ATRANV,AVERTI,AKD,AKE
      READ(5,30) AMTAU,RAMADA,RHOB,RHOW,ACCU,DT,TDISP,Q
      READ(5,30) (XDIM(I),I-1,NX),CBACK,UNTIM
      READ(5,30) (YDIM(I),I-1,NY)
      READ(5,30) (ZDIM(I),I-1,NZ)
      IF(NSOURS.NE.0) READ(5,30) (QS(I),I-1,NSOURS)
      IF(IWID.EQ.0) WIDTH-0.0
      IF(IDEP.EQ.0) DEPTH-0.0
C
C
C ------- PRINT TITLE, SYSTEM PARAMETERS AND CONTROL INPUTS
C
      WRITE(6,1000) (TITLE(I),I-1,20)
      WRITE(6,1001) CBACK,UNTIM
      WRITE(6,1100) NX,NY,NZ,NROOT,NBGTI,NEDTI,NPRINT,INSTAN,NSOURS,
     > INTER,ICASE
      WRITE(6,1200) DEPTH,WIDTH,RL1,RL2,RB1,RB2,RH1,RH2
      WRITE(6,1300) POR,HCOND,HGRAD,AELONG,ATRANV,AVERTI,AKD,AKE
      WRITE(6,1400) AMTAU,RAMADA,RHOB,ACCU,RHOW,DT,TDISP,Q
      IF(NSOURS.NE.0) WRITE(6,2000) (QS(I),I-1,NSOURS)
C
C
C ------- MAKE SOME PRELIMINARY COMPUTATIONS
C
      NTDISP-TDISP/DT + 1.0001
      XS-0.0
      YS-0.0
      ZS-0.0
      IF(RL1.EQ.RL2) XS-RL1
      IF(RB1.EQ.RB2) YS-RB1
      IF(RH1.EQ.RH2) ZS-RH1
      QTOTAL-Q
      IF(NSOURS.NE.0) Q-1.0
C
      FACTOR-1.0/(CP*RHOW)
      IF(ICASE.EQ.2) FACTOR-1.0E3
      IF(ICASE.EQ.3) FACTOR-1.0E6
      RATIO-1.0
      IF(RL1.NE.RL2) RATIO-RATIO/(RL2-RL1)
      IF(RB1.NE.RB2) RATIO-RATIO/(RB2-RB1)
      IF(RH1.NE.RH2) RATIO-RATIO/(RH2-RH1)
C
C
C ------- COMPUTE RETARDED VELOCITY, DISPERSION COEFFICIENTS, AND
C ------- OTHER PARAMETERS
C
      RETARD-1.0 + RHOB*AKD/POR
      UF-HCOND*HGRAD/(POR*RETARD)
      AKX-AELONG*UF+AMTAU/(POR*RETARD)
      AKY-ATRANV*UF+AMTAU/(POR*RETARD)
      AKZ-AVERTI*UF+AMTAU/(POR*RETARD)
      RKE-(AKE/(POR*RETARD))/AKZ
      ROTPAR-1.0E38
      IF(IDEP.NE.0) ROTPAR-RKE*DEPTH
C
      WRITE(6,1500) RETARD,UF,AKX,AKY,AKZ
C
C
C ------- COMPUTE RTY(I) AND AIY(I) FOR FINITE WIDTH CASE
C
      IF(IWID.EQ.0) GO TO 180
      DO 130 I-1,NROOT
      RTY(I)-I*PAI/WIDTH
  130 AIY(I)-2.0/WIDTH
C
C ------- WRITE OUT Y-EIGENVALUES AND Z-COEFFICIENTS
C
      IF(IBUG.EQ.0) GO TO 180
      WRITE(6,3100) (RTY(I),I-1,NROOT)
      WRITE(6,3200) (AIY(I),I-1,NROOT)
C
C
C ------- COMPUTE RTZ(I) AND AIZ(I) FOR FINITE DEPTH CASE
C
  180 IF(IDEP.EQ.0) GO TO 290
C
C ------- FOR THE THERMAL CASE, I.E. AKE NOT EQUAL TO 0.0
C
      IF(ICASE.NE.1) GO TO 250
      DO 200 I-1,NROOT
  200 CALL ROOT(RTZ,I,ROTPAR,MAXRUT)
      DO 210 I-1,NROOT
      RTZ(I) - RTZ(I)/DEPTH
      DENOMT-DEPTH*(1.0+RKE**2/RTZ(I)**2) + RKE/RTZ(I)**2
  210 AIZ(I)-2.0/DENOMT
      GO TO 285
C
C ------- FOR THE NON-THERMAL CASES
C
  250 DO 260 I-1,NROOT
      RTZ(I)-I*PAI/DEPTH
  260 AIZ(I)-2.0/DEPTH
C
C ------- WRITE OUT Z-EIGENVALUES AND Z-COEFFICIENTS
C
  285 IF(IBUG.EQ.0) GO TO 290
      WRITE(6,3300) (RTZ(I),I-1,NROOT)
      WRITE(6,3400) (AIZ(I),I-1,NROOT)
C
C
C ------- COMPUTE SOURCE PART OF EACH OF THE SERIES TERMS
C
C
C ------- COMPUTE SOURCE PART OF EACH OF Y-SERIES
C
  290 IF(IWID.EQ.0) GO TO 310
      DO 300 I-1,NROOT
      IF(RB1.EQ.RB2) PSIS(I)-COS(RTY(I)*YS)
      IF(RB1.NE.RB2) PSIS(I)-(WIDTH/(I*PAI))*(SIN(RTY(I)*RB2) -
     >      SIN(RTY(I)*RB1))
  300 CONTINUE
C
C ------- COMPUTE SOURCE PART OF EACH OF Z-SERIES
C
  310 IF(IDEP.EQ.0) GO TO 330
      DO 320 I-1,NROOT
      IF(RH1.EQ.RH2) PHIS(I)-COS(RTZ(I)*ZS)+RKE/RTZ(I)
     >     *SIN(RTZ(I)*ZS)
      IF(RH1.NE.RH2) PHIS(I)-(SIN(RTZ(I)*RH2)-SIN(RTZ(I)*RH1) -
     >      RKE/RTZ(I)*(COS(RTZ(I)*RH2)-COS(RTZ(I)*RH1)))/RTZ(I)
  320 CONTINUE
C
C ------- WRITE OUT THE YS-SERIES AND ZS-SERIES
C
  330 IF(IBUG.EQ.0) GO TO 350
      IF(IWID.NE.0) WRITE(6,3500) (PSIS(I),I-1,NROOT)
      IF(IDEP.NE.0) WRITE(6,3600) (PHIS(I),I-1,NROOT)
C
C
C ------- COMPUTE THE Y- AND Z-PART OF THE INTEGRAND
C ------- FOR EACH SERIES TERM
C
```

```
  350 DO 490 IT=1,NEDTI
      TIMED=(IT-1)*DT
      IF(IT.EQ.1) TIMED=DT
C
      DO 440 IY=1,NY
         Y=YDIM(IY)
C
C ------- TO EVALUATE THE FUNCTION Y1(Y,T;TAU) OR Y2(Y,T;TAU)
C
         IF(IWID.EQ.0) GO TO 420
         IF(IT.NE.1) GO TO 410
         FCTY(IY,IT)=0.0
         IF(RB1.EQ.RB2 .AND. Y.EQ.YS) FCTY(IY,IT)=1.0
         IF((RB1.NE.RB2) .AND. (Y.GE.RB1 .AND. Y.LE.RB2))
     >         FCTY(IY,IT)=1.0
         GO TO 440
  410         CALL SERIEY(SERY,Y,YS,RB1,RB2,WIDTH,TIMED,AKY,RTY,AIY,
     1         PSIS,MAXRUT,NROOT)
         IF(RB1.EQ.RB2) FCTY(IY,IT)=1.0/WIDTH+SERY
         IF(RB1.NE.RB2) FCTY(IY,IT)=(RB2-RB1)/WIDTH+SERY
         IF(RB1.EQ.0.0 .AND. RB2.EQ.WIDTH) FCTY(IY,IT)=1.0
         IF(FCTY(IY,IT).LT.0.0) FCTY(IY,IT)=0.0
         GO TO 440
C
C ------- TO EVALUATE THE FUNCTION Y3(Y,T;TAU) OR Y4(Y,T;TAU)
C
C
C ------- TO COMPUTE FUNCTION Y3
C
  420         IF(RB1.NE.RB2) GO TO 430
         IF(IT.NE.1) GO TO 425
         FCTY(IY,IT)=0.0
         IF(Y.EQ.YS) FCTY(IY,IT)=1.0
         GO TO 440
  425         Y1=SQRT(4.0*PAI*AKY*TIMED)
         EARG=(Y-YS)*(Y-YS)/(4.0*AKY*TIMED)
         IF(ABS(EARG).GT.100.0) EARG=170.0
         FCTY(IY,IT)=(1.0/Y1)*(EXP(-EARG))
         GO TO 440
C
C ------- TO COMPUTE FUNCTION Y4
C
  430         IF(IT.NE.1) GO TO 435
         FCTY(IY,IT)=0.0
         IF(Y.GE.RB1 .AND. Y.LE.RB2) FCTY(IY,IT)=1.0
         GO TO 440
  435         SRT=SQRT(4.0*AKY*TIMED)
C         FCTY(IY,IT)=(ERF((Y-RB1)/SRT)-ERF((Y-RB2)/SRT))/2.0
```

```
         FCTY(IY,IT)=(DERF((Y-RB1)/SRT)-DERF((Y-RB2)/SRT))/2.0
  440      CONTINUE
C
      DO 480 IZ=1,NZ
         Z=ZDIM(IZ)
C
C ------- TO EVALUATE THE FUNCTION Z1(Z,T;TAU) OR Z2(Z,T;TAU)
C
         IF(IDEP.EQ.0) GO TO 460
         IF(IT.NE.1) GO TO 450
         FCTZ(IZ,IT)=0.0
         IF(RH1.EQ.RH2 .AND. Z.EQ.ZS) FCTZ(IZ,IT)=1.0
         IF((RH1.NE.RH2) .AND. (Z.GE.RH1 .AND. Z.LE.RH2))
     >         FCTZ(IZ,IT)=1.0
         GO TO 480
  450        CALL SERIEZ(SERZ,Z,TIMED,AKZ,RKE,RTZ,AIZ,PHIS,MAXRUT,NROOT)
         FCTZ(IZ,IT)=SERZ
         IF(AKE.EQ.0. .AND. RH1.EQ.RH2) FCTZ(IZ,IT)=1.0/DEPTH+SERZ
         IF(AKE.EQ.0. .AND. RH1.NE.RH2) FCTZ(IZ,IT)=(RH2-RH1)/DEPTH+
     >         SERZ
         IF(RH1.EQ.0.0 .AND. RH2.EQ.DEPTH) FCTZ(IZ,IT)=1.0
         GO TO 480
C
C ------- TO EVALUATE THE FUNCTION Z3(Z,T;TAU) OR Z4(Z,T;TAU)
C
C
C ------- TO COMPUTE FUNCTION Z3
C
  460        IF(RH1.NE.RH2) GO TO 470
         IF(IT.NE.1) GO TO 465
         FCTZ(IZ,IT)=0.0
         IF(Z.EQ.ZS) FCTZ(IZ,IT)=1.0
         GO TO 480
C
  465        AKZT=4.0*AKZ*TIMED
         AKZTPI=AKZT*PAI
         AKZT4S=AKZT/4.0
         EARG1=(Z-ZS)*(Z-ZS)/AKZT
         EARG2=(Z+ZS)*(Z+ZS)/AKZT
         EARG3=AKZ*RKE*RKE*TIMED+RKE*(Z+ZS)
         ARG=(Z+ZS)/SQRT(AKZT) + RKE*SQRT(AKZT4S)
         TERM1=0.0
         IF(EARG1.LT.100.0) TERM1=EXP(-EARG1)/SQRT(AKZTPI)
         TERM2=0.0
         IF(EARG2.LE.100.0) TERM2=EXP(-EARG2)/SQRT(AKZTPI)
         TERM3=0.0
C         IF(EARG3.LT.100.0) TERM3=-RKE*EXP(EARG3)*(1.0-ERF(ARG))
         IF(EARG3.LT.100.0) TERM3=-RKE*EXP(EARG3)*(1.0-DERF(ARG))
      FCTZ(IZ,IT)=TERM1+TERM2+TERM3
      GO TO 480
C
C ------- TO COMPUTE FUNCTION Z4
C
 470        IF(IT.NE.1) GO TO 475
      FCTZ(IZ,IT)=0.0
      IF(Z.GE.RH1 .AND. Z.LE.RH2) FCTZ(IZ,IT)=1.0
      GO TO 480
C
 475        AKZT1=SQRT(4.0*AKZ*TIMED)
      AKZT2=AKZT1/2.0
      ARG1=(Z+RH2)/AKZT1
      ARG2=(Z+RH1)/AKZT1
      ARG3=(Z-RH2)/AKZT1
      ARG4=(Z-RH1)/AKZT1
      ARG5=AKZ*RKE*RKE*TIMED + RKE*(Z+RH2)
      ARG6=AKZ*RKE*RKE*TIMED + RKE*(Z+RH1)
C      TERMS4=0.5*(ERF(ARG1)-ERF(ARG2)-ERF(ARG3)+ERF(ARG4))
      TERMS4=0.5*(DERF(ARG1)-DERF(ARG2)-DERF(ARG3)+DERF(ARG4))
      TERM5=0.0
      IF(ARG5.LT.100.) TERM5=-EXP(ARG5)
   >        *(1.0-DERF(ARG1+RKE*AKZT2))
      TERM6=0.0
C      IF(ARG6.LT.100.) TERM6=EXP(ARG6)*(1.0-ERF(ARG2+RKE*AKZT2))
      IF(ARG6.LT.100.) TERM6=EXP(ARG6)*(1.0-DERF(ARG2+RKE*AKZT2))
C      TERM78=-(ERF(ARG1)-ERF(ARG2))
      TERM78=-(DERF(ARG1)-DERF(ARG2))
      FCTZ(IZ,IT)=TERMS4+TERM5+TERM6+TERM78
C
 480       CONTINUE
 490 CONTINUE
C
C
C ------- START TRANSIENT LOOP COMPUTATION
C
    TIME=0.0
    DO 800 ITT=NBGTI,NEDTI,NPRINT
C
    DO 710 IX=1,NX
      DO 710 IY=1,NY
        DO 710 IZ=1,NZ
 710           TEMPO(IX,IY,IZ)=TEMP(IX,IY,IZ)
C
    IF(INTER.EQ.0) GO TO 725
C
    IF(ICASE.EQ.1) WRITE(6,5100) TIME
    IF(ICASE.EQ.2) WRITE(6,5200) TIME
```

```
      IF(ICASE.EQ.3) WRITE(6,5300) TIME
C
      DO 720 IZOUT=1,NZ
         WRITE(6,6000) ZDIM(IZOUT)
  720         CALL ALLOUT(TEMP,XDIM,YDIM,ZDIM,IZOUT,NX,NY,NZ,
     >         MAXNX,MAXNY,MAXNZ)
C
  725      TIME=(ITT-1)*DT
C
      DO 760 IXX=1,NX
         X=XDIM(IXX)
         DO 750 IYY=1,NY
            Y=YDIM(IYY)
            DO 740 IZZ=1,NZ
            Z=ZDIM(IZZ)
C
C ------- BRANCH TO INSTANTANEOUS SOURCE OR CONTINUOUS SOURCE
C
            IF(INSTAN) 731,732,731
C
C ------- FOR THE CASE OF CONTINUOUS SOURCE FOR THE DURATION OF NTDISP
C
  731            IF(ITT.LE.NTDISP) CALL TINTEG(S,X,XS,RL1,RL2,
     >            FCTY,FCTZ,TIME,IYY,IZZ,ITT,UF,DT,AKX,RAMADA,QS,
     >            MAXNY,MAXNZ,MAXNTI,INSTAN)
            IF(ITT.GT.NTDISP) CALL TINTEG(S,X,XS,RL1,RL2,
     >            FCTY,FCTZ,TIME,IYY,IZZ,NTDISP,UF,DT,AKX,RAMADA,QS,
     >            MAXNY,MAXNZ,MAXNTI,INSTAN)
            GO TO 733
C
C ------- FOR THE CASE OF INSTANTANEOUS SOURCE RELEASE
C
  732            CALL TINTEG(S,X,XS,RL1,RL2,FCTY,FCTZ,TIME,IYY,IZZ,ITT,
     >            UF,DT,AKX,RAMADA,QS,MAXNY,MAXNZ,MAXNTI,INSTAN)
            S=S*2.0/DT
  733            TEMP(IXX,IYY,IZZ)=S*Q*RATIO*FACTOR/(POR*RETARD)
  740            CONTINUE
  750         CONTINUE
  760      CONTINUE
C
      IF(ITT.EQ.NBGTI) GO TO 800
      IF(NSOURS.NE.0) GO TO 800
C
C ------- CHECK IF STEADY STATE SOLUTION HAS BEEN OBTAINED
C ------- BEFORE THE FINIAL SIMULATING TIME
C
      DIFMAX=0.0
      DO 770 IX=1,NX
```

```
         DO 770 IY-1,NY
            DO 770 IZ-1,NZ
            IF(TEMPO(IX,IY,IZ).EQ.0.0) GO TO 770
            DIF-ABS(TEMP(IX,IY,IZ)/TEMPO(IX,IY,IZ)-1.0)
            IF(DIF.LE.DIFMAX) GO TO 770
            DIFMAX-DIF
  770            CONTINUE
C
      IF(DIFMAX.LE.ACCU) GO TO 910
C
  800 CONTINUE
C
      WRITE(6,7000)
      GO TO 920
  910 WRITE(6,8000)
  920 CONTINUE
      IF(ICASE.EQ.1) WRITE(6,5100) TIME
      IF(ICASE.EQ.2) WRITE(6,5200) TIME
      IF(ICASE.EQ.3) WRITE(6,5300) TIME
      DO 930 IZOUT-1,NZ
      WRITE(6,6000) ZDIM(IZOUT)
  930      CALL ALLOUT(TEMP,XDIM,YDIM,ZDIM,IZOUT,NX,NY,NZ,
     >      MAXNX,MAXNY,MAXNZ)
C
      DO 950 IX-1,NX
      DO 950 IY-1,NY
         DO 950 IZ-1,NZ
  950            TEMP(IX,IY,IZ)-0.0
      GO TO 999
C
 9999 CONTINUE
C
   10 FORMAT(20A4)
   20 FORMAT(16I5)
   30 FORMAT(8F10.0)
 1000 FORMAT(1H1,////,5X,20A4,//)
 1001 FORMAT(1PE12.3,' BACKGROUND CONCENTRATION (MG/L)'/
     + E12.3,' UNSATURATED ZONE TRAVEL TIME (YRS)')
 1100 FORMAT(1H ,/5X,
     > 'NO. OF POINTS IN X-DIRECTION .......................',I5/5X,
     > 'NO. OF POINTS IN Y-DIRECTION .......................',I5/5X,
     > 'NO. OF POINTS IN Z-DIRECTION .......................',I5/5X,
     > 'NO. OF ROOTS: NO. OF SERIES TERMS .................',I5/5X,
     > 'NO. OF BEGINNING TIME STEPS .......................',I5/5X,
     > 'NO. OF ENDING TIME STEP ...........................',I5/5X,
     > 'NO. OF TIME INTERVALS FOR PRINTED OUT SOLUTION ....',I5/5X,
     > 'INSTANTANEOUS SOURCE CONTROL - 0 FOR INSTANT SOURCE',I5/5X,
     > 'SOURCE CONDITION CONTROL - 0 FOR STEADY SOURCE ....',I5/5X,
     > 'INTERMITTENT OUTPUT CONTROL - 0 NO SUCH OUTPUT ....',I5/5X,
     > 'CASE CONTROL -1 THERMAL, - 2 FOR CHEMICAL, - 3 RAD ',I5/)
 1200 FORMAT(1H ,/5X,
     > 'AQUIFER DEPTH, - 0.0 FOR INFINITE DEEP (METERS) ...',E12.4/5X,
     > 'AQUIFER WIDTH, - 0.0 FOR INFINITE WIDE (METERS) ...',E12.4/5X,
     > 'BEGIN POINT OF X-SOURCE LOCATION (METERS) .........',E12.4/5X,
     > 'END POINT OF X-SOURCE LOCATION (METERS) ...........',E12.4/5X,
     > 'BEGIN POINT OF Y-SOURCE LOCATION (METERS) .........',E12.4/5X,
     > 'END POINT OF Y-SOURCE LOCATION (METERS) ...........',E12.4/5X,
     > 'BEGIN POINT OF Z-SOURCE LOCATION (METERS) .........',E12.4/5X,
     > 'END POINT OF Z-SOURCE LOCATION (METERS) ...........',E12.4/)
 1300 FORMAT(1H ,/5X,
     > 'POROSITY ...........................................',E12.4/5X,
     > 'HYDRAULIC CONDUCTIVITY (METER/HOUR) ...............',E12.4/5X,
     > 'HYDRAULIC GRADIENT ................................',E12.4/5X,
     > 'LONGITIDUNAL DESPERSIVITY (METER) .................',E12.4/5X,
     > 'LATERAL DISPERSIVITY (METER) ......................',E12.4/5X,
     > 'VERTICAL DISPERSIVITY (METER) .....................',E12.4/5X,
     > 'DISTRIBUTION COEFFICIENT, KD (M**3/KG) ............',E12.4/5X,
     > 'HEAT EXCHANGE COEFFICIENT (KCAL/HR-M**2-DEGREE C)..',E12.4/)
 1400 FORMAT(1H ,/5X,
     > 'MOLECULAR DIFFUSION MULTIPLY BY TOROSITY (M**2/HR) ',E12.4/5X,
     > 'DECAY CONSTANT (PER HOUR) .........................',E12.4/5X,
     > 'BULK DENSITY OF THE SOIL (GRAM/CM**3) .............',E12.4/5X,
     > 'ACCURACY TOLERANCE FOR REACHING STEADY STATE ......',E12.4/5X,
     > 'DENSITY OF WATER (KG/M**3) ........................',E12.4/5X,
     > 'TIME INTERVAL SIZE FOR THE DESIRED SOLUTION (HR) ..',E12.4/5X,
     > 'DISCHARGE TIME (HR) ...............................',E12.4/5X,
     > 'WASTE RELEASE RATE (KCAL/HR), (KG/HR), OR (CI/HR) .',E12.4/)
 1500 FORMAT(1H0,/5X,
     > 'RETARDATION FACTOR ................................',E12.4/5X,
     > 'RETARDED DARCY VELOCITY (M/HR) ....................',E12.4/5X,
     > 'RETARDED LONGITUDINAL DISPERSION COEF. (M**2/HR) ..',E12.4/5X,
     > 'RETARDED LATERAL DIEPSERSION COEFFICIENT (M**2/HR) ',E12.4/5X,
     > 'RETARDED VERTICAL DISPERSION COEFFICIENT (M**2/HR).',E12.4/)
 2000 FORMAT(1H0,4X,'LIST OF TRANSIENT SOURCE RELEASE RATE'/(5X,8E12.3)
     >)
 3100 FORMAT(1H1,4X,'LIST OF Y-EIGENVALUES'/(5X,10E12.4))
 3200 FORMAT(1H0,4X,'LIST OF Y-COEFFICIENT'/(5X,10E12.4))
 3300 FORMAT(1H1,4X,'LIST OF Z-EIGENVALUES'/(5X,10E12.4))
 3400 FORMAT(1H0,4X,'LIST OF Z-COEFFICIENTS'/(5X,10E12.4))
 3500 FORMAT(1H1,4X,'LIST OF YS-SERIES'/(5X,10E12.4))
 3600 FORMAT(1H0,4X,'LIST OF ZS-SERIES'/(5X,10E12.4))
 5100 FORMAT(1H1,4X,'TEMPERATURE DISTRIBUTION IN DEGREE C AT ',E12.4,'
     > HOURS')
 5200 FORMAT(1H0,4X,'DISTRIBUTION OF CHEMICALS IN PPB AT',E12.4,' HRS')
 5300 FORMAT(1H1,4X,'DISTRIBUTION OF RAD WASTE IN PCI AT ',E12.4,' HRS')
 6000 FORMAT(1H0,20X,'Z - ',F10.2)
 7000 FORMAT(1H0,'STEADY STATE SOLUTION HAS NOT BEEN REACHED BEFORE FINA
     >L SIMULATING TIME'//)
 8000 FORMAT(1H0,'STEADY STATE SOLUTION HAS BEEN OBTAINED BEFORE FINAL
     > SIMULATING TIME'//)
      RETURN
      END
      SUBROUTINE ROOT(RTZ,I,ROTPAR,MAXRUT)
C
C****************************************************
C    CHANGE 6/22/82
C
     IMPLICIT REAL*4 (A-H,O-Z)
C
C*********************************************************
      DIMENSION RTZ(MAXRUT)
C
      ZL=RTZ(I)
      IF(I.GT.1) ZL=RTZ(I-1)+0.01
  100 ZL=ZL+0.01
      FZL=ZL*SIN(ZL)-ROTPAR*COS(ZL)
      ZR=ZL+0.01
      FZR=ZR*SIN(ZR)-ROTPAR*COS(ZR)
      IF(FZL*FZR.LT.0.0) GO TO 200
      GO TO 100
  200 FZL=ZL*SIN(ZL)-ROTPAR*COS(ZL)
      DO 300 J=1,6
      ZH=(ZL+ZR)/2.0
      FZH=ZH*SIN(ZH)-ROTPAR*COS(ZH)
      IF(FZH*FZL.LE.0.0) GO TO 400
      ZL=ZH
      FZL=FZH
      GO TO 300
  400 ZR=ZH
  300 CONTINUE
      RTZ(I)=(ZL+ZR)/2.0
      RETURN
      END
      SUBROUTINE SERIEY(SER,Y,YS,RB1,RB2,B,TIMED,AKY,RTY,AIY,
     > PSIS,MAXRUT,NROOT)
C
C****************************************************
C    CHANGE 6/22/82
C
     IMPLICIT REAL*4 (A-H,O-Z)
C
C*********************************************************
      DIMENSION RTY(MAXRUT),AIY(MAXRUT),PSIS(MAXRUT)
      DIMENSION YTEUL(15)
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C
      EPS=0.0001
      IER=1
      I=1
      M=1
      N=1
      ASSIGN 100 TO IFC
      GO TO 500
  100 YTEUL(1)=FCT
      SUM=YTEUL(1)*0.5
    3 J=0
    4 I=I+1
      IF(I-NROOT) 5,5,12
    5 N=I
      ASSIGN 200 TO IFC
      GO TO 500
  200 AMN=FCT
      DO 6 K=1,M
      AMP=(AMN+YTEUL(K))*0.5
      YTEUL(K)=AMN
    6 AMN=AMP
      IF(ABS(AMN)-ABS(YTEUL(M))) 7,9,9
    7 IF(M-15) 8,9,9
    8 M=M+1
      YTEUL(M)=AMN
      AMN=0.5*AMN
    9 SUM=SUM+AMN
      IF(ABS(AMN)-EPS*ABS(SUM)) 10,10,3
   10 J=J+1
      IF(J-5) 4,11,11
   11 IER=0
   12 SER=SUM
      IF(IER.NE.0) WRITE(6,1000) Y,TIMED
      RETURN
C
C ------- TO EVALUATE N-TH TERM OF Y1(Y,T;TAU) OR Y2(Y,T;TAU)
C
  500 AKYTB=AKY*TIMED/(B*B)
      IF(AKYTB.LE.0.0000014) GO TO 510
      EARG=RTY(N)*RTY(N)*AKY*TIMED
      IF(EARG.GT.100.0) FCT=0.0
      IF(EARG.LE.100) FCT=AIY(N)*(COS(RTY(N)*Y))*PSIS(N)*EXP(-EARG)
      GO TO 590
  510 IF(RB1.NE.RB2) GO TO 520
      AKYTPI=4.0*3.141593*AKY*TIMED
      AKYT=4.0*AKY*TIMED
      EARG1=((Y-YS)-2.0*N*B)*((Y-YS)-2.0*N*B)/AKYT
      EARG2=((Y-YS)-2.0*(N-1)*B)*((Y-YS)-2.0*(N-1)*B)/AKYT
      EARG3=((Y+YS)-2.0*(N+1)*B)*((Y+YS)-2.0*(N+1)*B)/AKYT
      EARG4=((Y+YS)-2.0*N*B)*((Y+YS)-2.0*N*B)/AKYT
      FCT=(EXP(-EARG1)+EXP(-EARG2)+EXP(-EARG3)+EXP(-EARG4))
     >/SQRT(AKYTPI)
      GO TO 590
  520 AKY=SQRT(4.0*AKY*TIMED)
      ARG1=Y-RB1-2.0*N*B
      ARG2=Y-RB2-2.0*N*B
      ARG3=Y-RB1-2.0*(N-1)*B
      ARG4=Y-RB2-2.0*(N-1)*B
      ARG5=Y+RB1-2.0*(N+1)*B
      ARG6=Y+RB2-2.0*(N+1)*B
      ARG7=Y+RB1-2.0*N*B
      ARG8=Y+RB2-2.0*N*B
C      FCT=0.5*(ERF(ARG1)-ERF(ARG2)+ERF(ARG3)-ERF(ARG4)
C     > -ERF(ARG5)+ERF(ARG6)-ERF(ARG7)+ERF(ARG8))
      FCT=0.5*(DERF(ARG1)-DERF(ARG2)+DERF(ARG3)-DERF(ARG4)
     > -DERF(ARG5)+DERF(ARG6)-DERF(ARG7)+DERF(ARG8))
  590 GO TO IFC, (100,200)
C
 1000 FORMAT(1H0,10X,'WARNING: SERIESY AT Y =',F8.2,'  TIMED=',F8.2,'
     1NEEDS MORE TERMS')
      END
      SUBROUTINE SERIEZ(SER,Z,TIMED,AKZ,RKE,RTZ,AIZ,PHIS,MAXRUT,NROOT)
C
C*****************************************************
C    CHANGE 6/22/82
C
     IMPLICIT REAL*4 (A-H,O-Z)
C
C**********************************************************
      DIMENSION RTZ(MAXRUT),AIZ(MAXRUT),PHIS(MAXRUT)
      DIMENSION YTEUL(15)
C
      EPS=0.0001
      IER=1
      I=1
      M=1
      N=1
      ASSIGN 100 TO IFC
      GO TO 500
  100 YTEUL(1)=FCT
      SUM=YTEUL(1)*0.5
    3 J=0
    4 I=I+1
      IF(I-NROOT) 5,5,12
    5 N=I
      ASSIGN 200 TO IFC
      GO TO 500
  200 AMN=FCT
      DO 6 K=1,M
      AMP=(AMN+YTEUL(K))*0.5
      YTEUL(K)=AMN
    6 AMN=AMP
      IF(ABS(AMN)-ABS(YTEUL(M))) 7,9,9
    7 IF(M-15) 8,9,9
    8 M=M+1
      YTEUL(M)=AMN
      AMN=0.5*AMN
    9 SUM=SUM+AMN
      IF(ABS(AMN)-EPS*ABS(SUM)) 10,10,3
   10 J=J+1
      IF(J-5) 4,11,11
   11 IER=0
   12 SER=SUM
      IF(IER.NE.0) WRITE(6,1000) Z,TIMED
      RETURN
C
C ------- TO EVALUATE THE N-TH TERM OF Z1(Z,T;TAU) OR Z2(Z,T;TAU)
C
  500 EARG=RTZ(N)**2*AKZ*TIMED
      IF(EARG.GT.100.0) FCT=0.0
      IF(EARG.LE.100) FCT=AIZ(N)*(COS(RTZ(N)*Z)+RKE/RTZ(N)*
     1 SIN(RTZ(N)*Z))*PHIS(N)*EXP(-EARG)
      GO TO IFC, (100,200)
C
 1000 FORMAT(1H0,10X,'WARNING: SERIESZ AT Z =',F8.2,'  TIMED=',F8.2,'
     1NEEDS MORE TERMS')
      END
      SUBROUTINE TINTEG(S,X,XS,RL1,RL2,FCTY,FCTZ,TIME,IYY,IZZ,ITT,
     > UF,DT,AKX,RAMADA,QS, MAXNY,MAXNZ,MAXNTI,INSTAN)
C
C**************************************************
C    CHANGE 6/22/82
C
     IMPLICIT REAL*4 (A-H,O-Z)
C
C******************************************************
      DIMENSION FCTY(MAXNY,MAXNTI),FCTZ(MAXNZ,MAXNTI),QS(MAXNTI)
C
      PAI=3.1415927
      ITTM1=ITT-1
      N=ITTM1/2
      SUMEND=0.0
      SUMMID=0.0
      S=0.0
      ITAU=1
      ASSIGN 100 TO M
      GO TO 800
  100 FIT1=FIT
C
C ------- IF N .LT. 1, THEN THERE IS ONLY ONE INTERVAL
C
      IF(INSTAN.EQ.0) GO TO 700
      IF(N.LT.1) GO TO 700
      DO 400 K=1,N
      ITAU=K+K-1
C
C FOLLOWING COPIED INTO DO LOOP TO REPLACE ASSIGNED GOTO
C
C ------- TO EVALUATE THE FUNCTION X1(X,T;TAU) OR X2(X,T;TAU)
C
      XPART=0.0
      TIMD=TIME-(ITAU-1)*DT
      IF(ITAU.EQ.ITT) TIMD=0.01*DT
C
C ------- POINT SOURCE IN THE X-DIRECTION
C
      IF(RL1.NE.RL2) GO TO 220
       IF(ITAU.NE.ITT) GO TO 210
      XPART=0.0
      IF(X.EQ.XS) XPART=1.0
      GO TO 250
  210 EARG=((X-XS)-UF*TIMD)**2/(4.0*AKX*TIMD)
      IF(ABS(EARG).GT.150.) GO TO 250
      XPART=(1.0/(SQRT(4.0*PAI*AKX*TIMD)))*EXP(-EARG)
      GO TO 250
C
C ------- LINE SOURCE IN THE X-DIRECTION
C
  220 IF(ITAU.NE.ITT) GO TO 230
      XPART=0.0
      IF(X.GE.RL1 .AND. X.LE.RL2) XPART=0.0
      GO TO 250
  230 SRT=SQRT(4.0*AKX*TIMD)
      EAR=-UF*TIMD
      EARG1=(X-RL1+EAR)/SRT
      EARG2=(X-RL2+EAR)/SRT
C      XPART=(ERF(EARG1)-ERF(EARG2))/2.0
      XPART=(DERF(EARG1)-DERF(EARG2))/2.0
C
C ------- TO EVALUATE THE INTEGRAND, FIJK(X,Y,Z,T;TAU), IN EQ. 16
C
  250 IT=ITT-ITAU + 1
```

```
      FIT=XPART*FCTZ(IZZ,IT)*FCTY(IYY,IT)*QS(ITAU)*EXP(-RAMADA*TIMD)
  200 SUMEND=SUMEND+FIT
      ITAU=K+K
C
C FOLLOWING COPIED INTO DO LOOP TO REPLACE ASSIGNED GOTO
C
C ------- TO EVALUATE THE FUNCTION X1(X,T;TAU) OR X2(X,T;TAU)
C
      XPART=0.0
      TIMD=TIME-(ITAU-1)*DT
      IF(ITAU.EQ.ITT) TIMD=0.01*DT
C
C ------- POINT SOURCE IN THE X-DIRECTION
C
      IF(RL1.NE.RL2) GO TO 320
       IF(ITAU.NE.ITT) GO TO 310
      XPART=0.0
      IF(X.EQ.XS) XPART=1.0
      GO TO 350
  310 EARG=((X-XS)-UF*TIMD)**2/(4.0*AKX*TIMD)
      IF(ABS(EARG).GT.150.) GO TO 350
      XPART=(1.0/(SQRT(4.0*PAI*AKX*TIMD)))*EXP(-EARG)
      GO TO 350
C
C ------- LINE SOURCE IN THE X-DIRECTION
C
  320 IF(ITAU.NE.ITT) GO TO 330
      XPART=0.0
      IF(X.GE.RL1 .AND. X.LE.RL2) XPART=0.0
      GO TO 350
  330 SRT=SQRT(4.0*AKX*TIMD)
      EAR=-UF*TIMD
      EARG1=(X-RL1+EAR)/SRT
      EARG2=(X-RL2+EAR)/SRT
C      XPART=(ERF(EARG1)-ERF(EARG2))/2.0
      XPART=(DERF(EARG1)-DERF(EARG2))/2.0
C
C ------- TO EVALUATE THE INTEGRAND, FIJK(X,Y,Z,T;TAU), IN EQ. 16
C
  350 IT=ITT-ITAU + 1
      FIT=XPART*FCTZ(IZZ,IT)*FCTY(IYY,IT)*QS(ITAU)*EXP(-RAMADA*TIMD)
  300 SUMMID=SUMMID+FIT
  400 CONTINUE
C
C ------- IF N*2 .NE. ITTM1, THEN THERE ARE ODD NUMBERS OF INTERVALS
C
      IF(N*2 .NE. ITTM1) GO TO 500
      S=(2.0*SUMEND+4.0*SUMMID-FIT1)*DT/3.0
      GO TO 900
  500 ASSIGN 600 TO M
      ITAU=ITTM1
      GO TO 800
  600 S=(2.0*SUMEND+4.0*SUMMID-FIT1+FIT)*DT/3.0
  700 S=S+(FIT)*DT/2.0
      GO TO 900
C
C
C ------- COMPUTE FUNCTION VALUE OF THE INTEGRAND
C ------- FUNCTION F(ITAU)
C
C
C ------- TO EVALUATE THE FUNCTION X1(X,T;TAU) OR X2(X,T;TAU)
C
  800 XPART=0.0
      TIMD=TIME-(ITAU-1)*DT
      IF(ITAU.EQ.ITT) TIMD=0.01*DT
C
C ------- POINT SOURCE IN THE X-DIRECTION
C
      IF(RL1.NE.RL2) GO TO 820
       IF(ITAU.NE.ITT) GO TO 810
      XPART=0.0
      IF(X.EQ.XS) XPART=1.0
      GO TO 850
  810 EARG=((X-XS)-UF*TIMD)**2/(4.0*AKX*TIMD)
      IF(ABS(EARG).GT.150.) GO TO 850
      XPART=(1.0/(SQRT(4.0*PAI*AKX*TIMD)))*EXP(-EARG)
      GO TO 850
C
C ------- LINE SOURCE IN THE X-DIRECTION
C
  820 IF(ITAU.NE.ITT) GO TO 830
      XPART=0.0
      IF(X.GE.RL1 .AND. X.LE.RL2) XPART=0.0
      GO TO 850
  830 SRT=SQRT(4.0*AKX*TIMD)
      EAR=-UF*TIMD
      EARG1=(X-RL1+EAR)/SRT
      EARG2=(X-RL2+EAR)/SRT
C      XPART=(ERF(EARG1)-ERF(EARG2))/2.0
      XPART=(DERF(EARG1)-DERF(EARG2))/2.0
C
C ------- TO EVALUATE THE INTEGRAND, FIJK(X,Y,Z,T;TAU), IN EQ. 16
C
  850 IT=ITT-ITAU + 1
      FIT=XPART*FCTZ(IZZ,IT)*FCTY(IYY,IT)*QS(ITAU)*EXP(-RAMADA*TIMD)
      GO TO M,(100,600)
  900 RETURN
      END
      SUBROUTINE ALLOUT(FTV,XDIM,YDIM,ZDIM,IZ,NX,NY,NZ,
     > MAXNX,MAXNY,MAXNZ)
C
C*****************************************************
C    CHANGE 6/22/82
C
     IMPLICIT REAL*4 (A-H,O-Z)
C
C**********************************************************
      DIMENSION FTV(MAXNX,MAXNY,MAXNZ)
      DIMENSION XDIM(MAXNX),YDIM(MAXNY),ZDIM(MAXNZ)
C
      JOUT=(NX-1)/10+1
      DO 96 MM=1,JOUT
      JAA=10*(MM-1)+1
      JZZ=10*MM
      IF(MM.EQ.JOUT) JZZ=NX
      IF(MM.GT.1) WRITE(6,225)
  225 FORMAT(1H0,50X,'CONTINUE')
      WRITE(6,222) (XDIM(J),J=JAA,JZZ)
  222 FORMAT(1H ,60X,'X'/1X,'  Y ',10F12.0)
      WRITE(6,223)
  223 FORMAT(1H ,'    ',10(4X,'        '))
      DO 97 NN=1,NY
      Y=YDIM(NN)
      WRITE(6,224) Y, (FTV(J,NN,IZ),J=JAA,JZZ)
  224 FORMAT(1H,F5.0,10E12.3)
   97 CONTINUE
   96 CONTINUE
      RETURN
      END
C-----------------------------------------------
C *** USE (POSSIBLY) BETTER ERROR FUNCTION ***
C
C       FUNCTION DERF(X)
C
C DOUBLE PRECISION ERROR FUNCTION
C ORIGINAL CODING BY NEWBY-DEWBY
C
C    IMPLICIT REAL*4 (A-H,O-Z)
C    PI = 3.141592653589793
C    DERF = 2. / SQRT(PI) * (X - X*X*X/3. + X**5./10. - X**7./42. +
C    &   X**9./216. - X**11./1320.)
C    RETURN
C    END
```

```
C----------------------
      FUNCTION DERF(X)
C-----------------------------------------------------
C PURPOSE: TO CALCULATE THE ERROR FUNCTION
C-----------------------------------------------------
      IMPLICIT REAL*4 (A-H,O-Z)
C

      IF(X.NE.0.0) GO TO 1
      DERF = 0.0
      RETURN
1     DERF=1.0
      IF(X.GT.10) RETURN
      IF(X.GT.-10) GO TO 2
      DERF = -1.
      RETURN
2     XX=ABS(X)
      IF(XX.GT.2.5) GO TO 3
      T=1./(1.+.3275911*XX)
      Y=T*(.2548296-T*(.2844967-T*(1.421414-T*(1.453152-1.061405*T))))
      GO TO 4
3     Y=.5641896/(XX+.5/(XX+1./(XX+1.5/(XX+2./(XX+2.5/(XX+3./
     + (XX+1.)))))))
4     DERF=Y*EXP(-X*X)
C-----------------------------------------------------
C DERF AT THIS POINT IS THE COMPLIMENTARY ERROR FUNCTION
C WE WANT THE ERROR FUNCTION, SO SUBTRACT FROM 1
C-----------------------------------------------------
      DERF = 1 - DERF
      IF(X.LT.0.0) DERF = -DERF
      RETURN

      END
```

Appendix GG - Program RESULT

```
$NOFLOATCALLS
$STORAGE:2
C---------------------------------------
C *** RESULT.FLX ***
C
C PROGRAM READS OUTPUT FROM AT123D
C AND FINDS THE MAXIMUM CONCENTRATIONS
C
C FEB 1986
C ICF NORTHWEST
C MAR 1987 - ADD CADMIUM, 18-TH CHEMICAL
C
C---------------------------------------
      DIMENSION CHMNAM(5,16),CNAM(5),ADI(16)
      CHARACTER*55 TITLE
C-----------------------------
C   16 CONTAMINANTS SIMULATED:
C     6 METALS
C    10 ORGANICS
C-----------------------------
      DATA CHMNAM
     # /'ARSE','NIC ','    ','    ','    ',
     # 'CADM','IUM ','    ','    ','    ',
     # 'COPP','ER  ','    ','    ','    ',
     # 'LEAD','    ','    ','    ','    ',
     # 'MERC','URY ','    ','    ','    ',
     # 'NICK','EL  ','    ','    ','    ',
     # 'BENZ','ENE ','    ','    ','    ',
     # 'BENZ','O(A)','PYRE','NE  ','    ',
     # 'BIS(','2ETH','EX)P','THAL','ATE ',
     # 'CHLO','RDAN','E   ','    ','    ',
     # 'DDT/','DDE/','DDD ','    ','    ',
     # 'DIME','THYL','NITR','OSAM','INE ',
     # 'LIND','ANE ','    ','    ','    ',
     # 'PCBS','    ','    ','    ','    ',
     # 'TRIC','HLOR','OETH','YLEN','E   ',
     # 'TOXA','PHEN','E   ','    ','    '/
C-------------------------
C CHECK IF AT123D WAS RUN
C-------------------------
      OPEN  (1,FILE='FLAG.FLG',STATUS='OLD')
      READ  (1,*) UNSAT,ISAT
      CLOSE (1)
      IF(.NOT.(ISAT.EQ.0)) GO TO 32758
      WRITE (*,4)
4     FORMAT(//10X'*** ALL CONTAMINANTS PASSED ***'/
     # 4X'THE PRELIMINARY TIER 1 AND TIER 2 ANALYSES.'//
     # 4X'SEE THE SLUGMAIN.OUT FILE FOR A SUMMARY OF'/
     # 4X'THE PRELIMINARY TIER 1 AND TIER 2 ANALYSES.'/)
      OPEN (7,FILE-'RESULT.OUT',STATUS-'NEW')
      WRITE (7,4)
      CLOSE (7)
      STOP
C----------------
C OPEN INPUT FILE
C----------------
32758 OPEN (1,FILE-'SLUDGFIX.OUT',STATUS-'OLD')
      OPEN (2,FILE-'AT123D.OUT',STATUS-'OLD')
      OPEN (7,FILE-'RESULT.OUT',STATUS-'NEW')
C---------------------------------
C NOTIFICATION STATEMENT WRITTEN OUT
C---------------------------------
      WRITE (*,5)
5     FORMAT (//14X' PROGRAM:   RESULT'//)
C-----------------------------------------------------------------------
C READ EFFECTS THRESHOLD VALUES FROM "SLUGE.FIL", OUTPUT FROM "SLUDGFIX"
C-----------------------------------------------------------------------
      READ(1,8)
      DO 32757 I-1,16
      READ(1,8) ADI(I)
32757 CONTINUE
8     FORMAT(25X,E12.4)
      CLOSE (UNIT-1)
C--------------------------------
C LOOP THROUGH ALL CHEMICAL RESULTS
C--------------------------------
32756 IF(.NOT.(N.EQ.N)) GO TO 32755
      READ(2,10,END-99)CNAM,TITLE,CBACK,UNTIM
10    FORMAT(////6X,5A4,A55///E12.3/E12.3,50(/))
      WRITE(7,20) CNAM,TITLE
20    FORMAT(/5X,5A4,A55/)
C----------------------------------------------------------------
C MATCH CHEMICAL NAMES TO FIND INDEX FOR EFFECTS THRESHOLD VALUES
C----------------------------------------------------------------
      DO 32754 I-1,16
      DO 32753 J-1,5
      IF (CNAM(J).NE.CHMNAM(J,I)) GO TO 22
32753 CONTINUE
      GO TO 25
22    CONTINUE
32754 CONTINUE
C
00025 IF(.NOT.(I.GT.16)) GO TO 32752
      WRITE(*,27) CNAM
27    FORMAT(' *** CHEMICAL ',5A4,' NOT FOUND ***')
      STOP
```

```
32752 ICHEM = I
C-----------------------------------------------
C LOOP THROUGH RESULTS FOR THE ICHEM'TH CHEMICAL
C-----------------------------------------------
      CMAX  = 0.
      SATIM = 0.
32751 IF(.NOT.(N.EQ.N)) GO TO 32750
      READ(2,30,ERR=40) T,C
30    FORMAT(40X,E12.4/////6X,E12.3)
      IF(.NOT.(C.GT.CMAX)) GO TO 32749
      CMAX  = C
      SATIM = T
32749 GO TO 32751
32750 CONTINUE
40    READ(2,50) T,C
50    FORMAT(///40X,E12.4/////6X,E12.3)
      IF(.NOT.(C.GT.CMAX)) GO TO 32748
      CMAX  = C
      SATIM = T
C--------------------------------------------------------------
C CONVERT OUTPUT CONCENTRATION FROM PPB (MG/CU M) TO PPM (MG/L)
C--------------------------------------------------------------
32748 CMAX = CMAX * 0.001
      CSUM = CBACK + CMAX
C------------------------------------------------------------
C SUM UNSATURATED AND SATURATED TRAVEL TIMES TO PRODUCE TOTAL
C TRAVEL TIME
C------------------------------------------------------------
      TOTIM = SATIM + UNTIM
      WRITE(7,60) CSUM,ADI(ICHEM),CMAX,CBACK,UNTIM,SATIM,TOTIM
60    FORMAT(' PEAK CONCENTRATION AT THE MONITORING LOCATION (MG/L) ='
     + ,1PE10.2/
     + ' EFFECTS THRESHOLD VALUE (MG/L)',23X,'=',1PE10.2/
     + ' MAXIMUM CONCENTRATION CONTRIBUTED BY LANDFILL (MG/L) =',E10.2/
     + ' BACKGROUND CONCENTRATION (MG/L)',22X,'=',E10.2//
     + ' TRAVEL TIMES FOR THE PEAK CONCENTRATION (YRS) :'/
     + 37X,'UNSATURATED ZONE =',E10.2/
     + 39X,'SATURATED ZONE =',E10.2/
     + 17X,'TOTAL TRAVEL TIME THROUGH BOTH ZONES =',E10.2//65('-')/)
      GO TO 32756
C
32755 CONTINUE
99    STOP
      END
```

Appendix HH - Program ALLCON

```
$NOFLOATCALLS
$STORAGE:2
C------------------
C *** ALLCON.FLX ***
C
C ALLOWABLE CONCENTRATION
C
C COMPARE OUTFLOW CONCENTRATION + VAPOR CONCENTRATION WITH HEALTH EFFECT
C LEVEL (HEL) AND SCALE WET SLUDGE CONCENTRATION IN SLUDGFIX.OUT TO TRY
C TO PRODUCE THE HEL AT THE OUTFLOW BOUNDARY.
C---------------------------------------------
      CHARACTER*1 LINE(80)
      CHARACTER*10 CHEM(16)

      DIMENSION CS(16),HEL(16),CLO(16),BC(16)
      DIMENSION CHMNAM(5,16),CNAM(2)

      COMMON /VAPR/CLI(16),VC(16),H(16),RMW(16),
     + VEL,TEMP,PA,PT,TCA,TCP,XA,SITLEN,SITWID,DIST


      DATA CHEM/'ARSENIC   ','CADMIUM   ','COPPER    ',
     +          'LEAD      ','MERCURY   ','NICKEL    ',
     +          'BENZENE   ','B(A)P     ','BEHP      ','CHLORDANE ',
     +          'DDT       ','DMN       ','LINDANE   ','PCB       ',
     +          'TCE       ','TOXAPHENE '/
      DATA CHMNAM
     # /'ARSE','NIC ','    ','    ','    ',
     #       'CADM','IUM ','    ','    ','    ',
     #       'COPP','ER  ','    ','    ','    ',
     #       'LEAD','    ','    ','    ','    ',
     #       'MERC','URY ','    ','    ','    ',
     #       'NICK','EL  ','    ','    ','    ',
     #       'BENZ','ENE ','    ','    ','    ',
     #       'BENZ','O(A)','PYRE','NE  ','    ',
     #       'BIS(','2ETH','EX)P','THAL','ATE ',
     #       'CHLO','RDAN','E   ','    ','    ',
     #       'DDT/','DDE/','DDD ','    ','    ',
     #       'DIME','THYL','NITR','OSAM','INE ',
     #       'LIND','ANE ','    ','    ','    ',
     #       'PCBS','    ','    ','    ','    ',
     #       'TRIC','HLOR','OETH','YLEN','E   ',
     #       'TOXA','PHEN','E   ','    ','    '/

      DATA CLO/1.,37.,100.,10.,0.69,3.4,181.8,0.031,545.,0.117,
     + 107.5,515.,17.7,0.00621,84.0,20.4/

C
```

```
      OPEN (1,FILE='RESULT.OUT',STATUS='OLD')
      OPEN (2,FILE='SLUDGFIX.OUT',STATUS='OLD')
      OPEN (3,FILE='SLFIXN.OUT',STATUS='NEW')
      OPEN (4,FILE='SAT.INP',STATUS='OLD')
      OPEN (8,FILE='ALLCON.OUT',STATUS='NEW')
      WRITE (*,8)
8     FORMAT(//10X'PROGRAM ALLCON'//
     + ' ALLCON COMBINES THE AQUIFER, VAPOR, AND BACKGROUND'/
     + ' CONCENTRATIONS FOR COMPARISON WITH HEALTH EFFECTS LEVELS'//
     + '    ###########################################'/
     + '    #                                         #'/
     + '    # SEE FILE "ALLCON.OUT" FOR FINAL RESULTS #'/
     + '    #                                         #'/
     + '    ###########################################'/)
C--------------------------------
C WRITE HEADINGS TO OUTPUT FILES
C--------------------------------
      WRITE (8,20)
20    FORMAT(' CONCENTRATIONS IN MG/L, DRY WGHT IN MG/KG'//
     + ' CHEMICAL    AQUIFER   VAPOR  BCKGROUND',
     +       '    SUM       HEL    DRY WGHT      F'/
     + ' ---------- -------- -------- ---------',
     +       ' --------  --------  --------  --------')

C
C READ SOME NECESSARY VALUES FROM SLUDGFIX.OUT
C
      READ(2,60) LINE
      J = 80
32758 IF(.NOT.(LINE(J).EQ.' ' .AND. J.GT.1)) GO TO 32757
      J = J - 1
      GO TO 32758
32757 WRITE(3,60) (LINE(K),K=1,J)
      DO 32756 I=1,16
      READ (2,40) CLI(I),CS(I),HEL(I)
32756 CONTINUE
40    FORMAT(1X,3E12.4)
      READ (2,41) DIST,SITLEN,SITWID
41    FORMAT(////3(E12.4/)/)
      READ (2,*) NLAYER
      DO 42,I=1,NLAYER
42    READ (2,43)
43    FORMAT(5(/))
      READ (2,44)
44    FORMAT(41(/))
      READ (2,*) (BC(I),I=1,16)
      READ (2,*) VEL,TEMP,PA,PT,TCA,TCP,XA,(H(I),RMW(I),I=1,16)
      REWIND (2)
      READ (2,45)
45    FORMAT(16(/))

C-----------------------------------------------------
C CALL VAPOR TO CALCULATE CONTRIBUTIONS FROM VAPOR PATHWAY
C-----------------------------------------------------
      CALL VAPOR
C-------------------------------------------------------------
C LOOP THROUGH THE 16 CHEMICALS
C READING RESULTS & COMPARING WITH HEL (EFFECTS THRESHOLD VALUES)
C AND SCALING INPUTS FOR NEXT RUN
C-------------------------------------------------------------
      I = 0
32755 IF (I.GE.16) GO TO 32754
      I = I + 1
      CA = 0.
      IF (CS(I).LT.1.E-15 .OR. CLI(I).LT.1.E-15) GO TO 32
      READ(1,30,END=32,ERR=32) CNAM,CA
30    FORMAT(/5X,2A4,4(/)55X,E10.2,9(/))
32753 IF(CNAM(1).EQ.CHMNAM(1,I) .AND. CNAM(2).EQ.CHMNAM(2,I)) GOTO 32752
C-----------------------------------
C CHEMICAL NOT IN "RESULT.OUT"
C WRITE RESULTS & PROCESS CURRENT CHEM
C-----------------------------------
      CS0 = CS(I)
      C0  = 0.
      VCL = 0.01*VC(I)
32751 SUM = BC(I) + VCL
      IF (BC(I).LT.HEL(I)) GO TO 31
      CLI(I) = 0.
      CS(I)  = 0.
      F      = 0.
      GO TO 32750
31    IF (VCL.LE.0) GO TO 32749
      F = (HEL(I)-BC(I))/VCL
C-----------------------------------
C LIMIT THE NEW SLUDGE CONC TO 10 G/KG
C-----------------------------------
      IF (CS(I)*F.GT.10000.) F = 10000./CS(I)
      CS(I) = CS(I) * F
      IF (I.GT.6) CLI(I) = CLI(I) * F
      GO TO 32750
32749 CS(I) = 10000.
      F = 99.9
      IF (CS0.EQ.CS(I)) F = 1.0
32750 WRITE (3,48) CLI(I),CS(I),HEL(I)
      WRITE (8,50) CHEM(I),C0,VCL,BC(I),SUM,HEL(I),CS0,F
      I = I + 1
      GO TO 32753
32752 CONTINUE
32    TC = CA
      VCL = 0.
      CS0 = CS(I)
      IF (CS(I).LT.1.E-15) GO TO 46
C------------------------
C ADD VAPOR CONCENTRATION
C------------------------
      VCL = 0.01*VC(I)
      TC = CA + VCL
C-----------------
C CALCULATE FACTOR
C-----------------
32748 F = 1.0
      IF (TC.GT.0) F = (HEL(I)-BC(I))/TC
      IF (F.LT.0.) F = 0.0
      IF (ABS(F-1.).LT.0.01) F = 1.0
C-----------------------------------------
C LIMIT THE NEW SLUDGE CONC TO 10000 MG/KG
C-----------------------------------------
      IF (CS(I)*F.GT.10000.) F = 10000./CS(I)
      CS(I) = CS(I) * F
      IF (I.GT.6) CLI(I) = CLI(I) * F
      GO TO 47
46    CLI(I) = CLO(I)
      CS(I) = 10000.
      F = 99.9
C-----------------------------------
C -- WRITE NEW VALUES TO SLFIXN.OUT
C-----------------------------------
47    WRITE (3,48) CLI(I),CS(I),HEL(I)
48    FORMAT(1X,1P3E12.4)
      SUM = BC(I) + CA + VCL
      WRITE (8,50) CHEM(I),CA,VCL,BC(I),SUM,HEL(I),CS0,F
50    FORMAT(1X,A10,1P3E9.2,4E10.2)
      GO TO 32755
C---------------------------------------
C READ & WRITE THE REST OF SLUDGFIX.OUT
C---------------------------------------
32754 DO 32747 I=1,1000
      READ (2,60,END=99) LINE
      J = 80
32746 IF(.NOT.(LINE(J).EQ.' ' .AND. J.GT.1)) GO TO 32745
      J = J - 1
      GO TO 32746
32745 WRITE (3,60) (LINE(K),K=1,J)
```

```
60    FORMAT(80A1)
32747 CONTINUE
C
99    STOP
      END

      SUBROUTINE VAPOR
C--------------------------------------------------------------------------
C *** VAPOR.FOR ***
C
C CALCULATION OF CONCENTRATION DUE TO VAPOR PATHWAY
C
C INDEX - INDEX OF CHEMICAL TO BE ANALYZED
C VEL        - AVERAGE WIND VELOCITY OVER LANDFILL (M/S)
C TEMP       - AVERAGE AIR TEMPERATURE (DEG C)
C PA    - AIR-FILLED POROSITY OF COVER SOIL
C PT    - TOTAL POROSITY OF COVER SOIL
C TCA        - COVER THICKNESS ACTIVE (M)
C TCP        - COVER THICKNESS POST-CLOSURE (M)
C XA    - CHARACTERISTIC SITE LENGTH (M) DURING ACTIVE PERIOD
C XP    - "         "     "     "     "     POST-CLOSURE
C
C CL    - LEACHATE CONCENTRATION FOR 16 CHEMICALS
C RL    - LENGTH OF LANDFILL (REPOSITORY) (M)
C RB    - WIDTH (BASE) OF LANDFILL (M)
C
C H     - MODIFIED HENRY'S LAW CONSTANTS (DIMENSIONLESS)
C SIGMA - STANDARD DEVIATION OF VERTICAL CONTAMINANT DISTRUBTION (M)
C       - A*X**B
C SIGA       - A IN ABOVE EQUATION
C SIGB       - B IN ABOVE EQUATION
C RMW        - MOLECULAR WEIGHT OF CONTAMINANT
C--------------------------------------------------------------------------
      CHARACTER*1 FILE(20)
      COMMON /VAPR/C(16),VC(16),H(16),RMW(16),
     + VEL,TEMP,PA,PT,TCA,TCP,XA,SITLEN,SITWID,DIST
      DIMENSION SIGA(10),SIGB(10)
C
C      DATA H/1.7E-08,0.004625,0.002,0.0017,0.02,0.16/
C      DATA RMW/252.32,391.,410.,354.5,74.08,300./
C-----------------------------------------------
      DATA SIGA/15.209,14.457,13.953,13.953,14.823,16.187,17.836,
     +       22.651,27.084,34.219/
      DATA SIGB/0.81558,0.78407,0.68465,0.63227,0.54503,0.46490,
     +       0.41507,0.32681,0.27436,0.21716/
C     DATA CL/6.0E-06,25.,0.00014,0.01,0.014,1.8E-06/
C---------------------------------------------------
      XP = SQRT(SITLEN*SITWID)
```

```
C-----------------------------------------------
C CALCULATE SIGMA
C USE DISTANCE TO COMPLIANCE POINT IN KILOMETERS
C-----------------------------------------------
32758 R  = 0.5 * SITLEN + DIST
      RK = 0.001*R
      IF(.NOT.(RK.LE.0.2)) GO TO 32756
      I = 1
      GO TO 300
32756 IF(.NOT.(RK.LE.0.7)) GO TO 32755
      I = 2
      GO TO 300
32755 IF(.NOT.(RK.LE.1.00)) GO TO 32754
      I = 3
      GO TO 300
32754 IF(.NOT.(RK.LE.2.00)) GO TO 32753
      I = 4
      GO TO 300
32753 IF(.NOT.(RK.LE.3.00)) GO TO 32752
      I = 5
      GO TO 300
32752 IF(.NOT.(RK.LE.7.00)) GO TO 32751
      I = 6
      GO TO 300
32751 IF(.NOT.(RK.LE.15.0)) GO TO 32750
      I = 7
      GO TO 300
32750 IF(.NOT.(RK.LE.30.0)) GO TO 32749
      I = 8
      GO TO 300
32749 IF(.NOT.(RK.LE.60.0)) GO TO 32748
      I = 9
      GO TO 300
32748 I = 10
300   SIGMA = SIGA(I) * RK**SIGB(I)
C---------------------------------------------------------------------
C SET CONSTANTS COMMON TO ALL CHEMICALS
C   BEGIN CALCULATING QA,QC,QCP
C   QA = FLUX RATE FOR OPEN (AIR) PERIOD DURING ACTIVE PERIOD
C   QC =   "    "     "  CLOSED PERIOD DURING ACTIVE PERIOD
C   QCP =  "    "   DURING POST-CLOSURE PERIOD
C   XYA, XYP = ACTIVE & POST-CLOSURE LATERAL VIRTUAL DISTANCES
C   SRRA,SRRP = ACTIVE & POST-CLOSURE SRR VALUES
C---------------------------------------------------------------------
      QA0 = 0.17*VEL*0.994**(TEMP-20.)
      QC0 = 0.000092*PA**3.333*1.006**(TEMP-20)/PT/PT/TCA
      QCP0 = QC0*TCA/TCP
      XYA  = 2.8364 * XA
      XYP  - 2.8364 * XP
      SRRA - 2032000.*XA*XA/( (R+XYA)*VEL*SIGMA )
      SRRP - 2032000.*XP*XP/( (R+XYP)*VEL*SIGMA )
C-----------------------------------
C LOOP THROUGH THE 16 CHEMICALS
C   VC - VAPOR CONCENTRATION
C-----------------------------------
      DO 32747 I-1,16
      CV - H(I) * C(I)
C-----------------------------------------------------------
C CALCULATE:
C QA - EMISSION RATE (G/M2-S) DURING ACTIVE PERIOD
C QC -          "     "     "        "       "   COVERED PERIOD
C QCP -   "      "      "       "    COVERED POST-CLOSURE
C-----------------------------------------------------------
      VS  - CV/SQRT(RMW(I))
      QA  - QA0*VS
      QC  - QC0*VS
      QCP - QCP0*VS
C-------------------------------------------------------------------
C CALCULATE TIME WEIGHTED AVERAGE FLUX RATES
C   QWA - WEIGHTED AVE FLUX RATE FOR ACTIVE PERIOD
C   QWP -    "       "    "    "    "  POST-CLOSURE PERIOD
C   ASSUME THE SLUDGE IS OPEN TO THE AIR 4 HOURS PER DAY (1/6 DAY)
C   ASSUME LANDFILL IS ACTIVE 20 YR OUT OF 70
C     (2/7 OF TIME - 0.2857142857...)
C     ALL THE SITE IS CLOSED FOR 50 YRS & ON AVERAGE HALF IS CLOSED
C     THE FIRST 20, SO ON AVERAGE ALL THE SITE IS CLOSED FOR 60 YRS
C     OR 60/70 - 0.857142857... OF THE TIME.
C-------------------------------------------------------------------
      QW  - QA*0.1666667 + QC*0.8333333
      QWA - QW*0.2857142
      QWP - QCP*0.8571428
C----------------------------------------
C CALCULATE VAPOR CONC FOR ACTIVE PERIOD
C  2.84 - 1/SQRT(PI) * COT(1/2*22.5DEG)
C----------------------------------------
      CA  - QWA * SRRA
C----------------------------------------------------
C CALCULATE CP - QWP * SRR,
C THE VAPOR CONCENTRATION DUE TO POST-CLOSURE RELEASES
C----------------------------------------------------
      CP  - QWP * SRRP
C---------------------------------------------------------
C SUM THE ACTIVE CONTRIBUTION AND POST-CLOSURE CONTRIBUTION
C TO OBTAIN TOTAL CONCENTRATION
C---------------------------------------------------------
      CT - CA + CP
      VC(I) = CT
32747 CONTINUE
C
999   RETURN
      END
```